WATER QUALITY INVENTORY AND MANAGEMENT PLAN

MIDDLE YELLOWSTONE RIVER BASIN
MONTANA

by

WATER QUALITY BUREAU
ENVIRONMENTAL SCIENCES DIVISION
Montana Department of Health and Environmental Sciences

PRELIMINARY
DRAFT

WATER QUALITY INVENTORY AND MANAGEMENT PLAN
MIDDLE YELLOWSTONE RIVER BASIN

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I. INTRODUCTION

This report presents information relative to water quality and water quality management in the Middle Yellowstone River Basin (Plate I). This is the middle segment of the total Yellowstone Basin and is one of sixteen basins designated by the State of Montana for preparation of water quality management plans. The Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) have directed states to prepare such plans as part of a nationwide program for controlling water pollution. This act states that not later than July 1, 1977, effluent limitations for point sources, other than publicly owned treatment works, shall require the application of best practical control technology available. For publicly owned treatment works in existence on July 1, 1977, effluent limitation will be based on secondary treatment.

The objectives of this effort are to provide the state with water quality data and related information to (1) determine the water quality characteristics of all natural and waste waters, (2) determine what factors both natural and man-made effect the quality of waters, (3) develop a management strategy for maintaining and enhancing the quality of waters in the Middle Yellowstone Basin, and (4) provide information needed to determine whether Montana's water quality standards are and will continue to be met. Also included is a description of physical characteristics of the basin.

The general methodology used in this study was the compilation and evaluation of existing water quality data and related information. Where data and information was deficient, field investigations and water and wastewater sampling and analysis were completed to obtain the needed information.

This investigation does not present a detailed analysis of the areas' resources, but summarizes water quality related information. As additional information becomes available, the Middle Yellowstone River Basin Water Quality Management Plan will be revised and updated as part of Montana's continuing planning process.

Assistance in obtaining information for this report was obtained from a number of agencies and persons. The Department of Natural Resources provided information on land use, water use, economy and population. The U. S. D. A. Soil Conservation Service provided information on soils and irrigation.

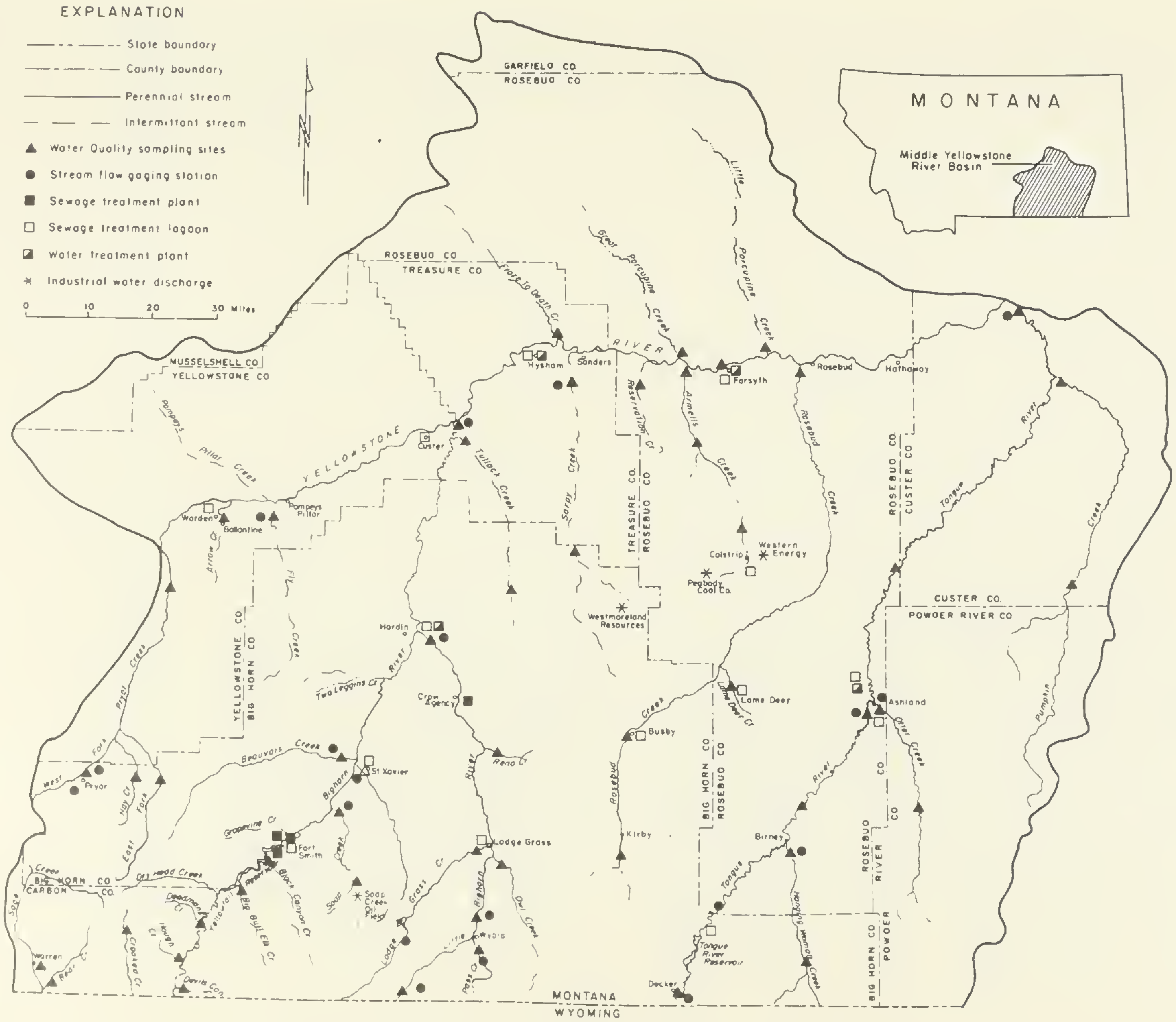

Figure 1 — Sketch map showing Middle Yellowstone River Basin

II. RELATED INVESTIGATIONS AND PLANS

BASIN-WIDE WATER QUALITY RELATED STUDIES

The Department of Natural Resources, Energy Planning Division, is conducting an environmental impact study of the proposed electric generating units 3 and 4 at Colstrip. Contracts for technical assistance in this study have been awarded to various state and federal agencies. The following agencies have been awarded contracts to study water quality or water quality related resources. The water quality assessment for both surface and groundwater was conducted by the Montana State Department of Health and Environmental Sciences, Water Quality Bureau. The fisheries biology study along with benthic invertebrate surveys are being conducted by the Montana Fish and Game Department. The Energy Planning Division has contracted the Montana State Department of Intergovernmental Relations to determine the additional needs for municipal water and sewer facilities in the Colstrip area. Dr. Gordon of the University of Montana is examining rainfall chemistry and predicting the impact of SO_2 and water vapor emissions in the Colstrip area. The Missouri Basin Comprehensive Framework Study (Ref. 20) broadly described water quality and related resources of the entire Upper Missouri River Basin of which the Middle Yellowstone River Basin is a portion. The North Central Power Study (Ref. 13) was a broad planning effort directed at coal development. It discussed energy distribution, coal resources, and pollution in southeastern Montana as part of the Fort Union and Powder River basin formations.

This has been followed by an ongoing program of the Northern Great Plains Resource Program (NGPRP). It is the aim of the Water Quality Subgroup of the NGPRP to provide, in part, alternative methods of development of water resources in southeastern Montana. The NGPRP has contracted with federal and state agencies for the collection of additional water quality related data that the subgroup felt was needed to achieve their goal. The U. S. Geological Survey, Water Resources Division, has received funding from the Northern Great Plains Resource Program to set up several water quality monitoring stations within the Middle Yellowstone River Basin. The Northern Great Plains Resource Program has contracted with the University of Montana to study the effects of in-stream flow variations on associated biological activity.

Agencies assessing the data and information for the NGPRP Water Quality Subgroup are the U. S. Environmental Protection Agency (EPA), the U. S. Bureau of Sport Fisheries and Wild-

life (BSF & W), and the U. S. Bureau of Reclamation (BuRec). Their input into the NGPRP is one of assessment only; the actual data collected is contracted out to other federal and state agencies. Tishler and Shaw (members of the NGPRP) are writing a report on water requirements of generating facilities and spoil bank leaching.

Several additional studies are being completed by federal agencies in the region. EPA funded a water quality related study of Yellowtail Reservoir (Bighorn Lake) and the Bighorn River (Ref. 16). They have also initiated a four-year study of envirionmental effects caused by trace elements from coal-fired, power stations. The Bureau of Land Management (BLM) and the USGS in a joint effort are studying the water quality of shallow wells in the Ashland area. The BSF & W is preparing part of an envirionmental impact statement for the U. S. Bureau of Indian Affairs (BIA) for coal leases on the Crow and Northern Cheyenne Indian Reservations. This is in addition to their contribution to the NGPRP. In addition to their input into the NGPRP, the BuRec published an aqueduct study (Ref. 14) and a report on the resources of basins in eastern Montana (Ref. 15). Within these reports the water quality and related resources are broadly described for the Middle Yellowstone Basin. The BuRec has initiated a total water management study for the Yellowstone Basin. The first phase of the study is an analysis of the effectiveness of existing water use within the basin. As a part of this study, the Montana State Water Quality Bureau has been contracted to do water quality analysis of water from irrigation intakes on the Yellowstone River mainstem and several tributaries.

The BLM and the U. S. Forest Service (USFS) in an inter-agency project conducted a land use study of the Pryor Mountains. This study pointed out the degradation of Crooked Creek by increased siltation caused by wild horse and cattle grazing (Ref. 17, 22). The BLM and USFS are just finishing another inter-agency project, "The Birney-Decker Resource Study." This study was initiated as a result of federal leases for coal and other energy related developments in the area. At this time a new BLM project is getting underway. This project is an environmental impact study of energy related development on federal lands in the Colstrip area and on the proposed transmission lines from Colstrip to the hot springs area near Broadview. Also, included in this study is to be a discussion of the impact that development in this area will have on energy availability from Chicago to Seattle. The final report of this study is to be in the form of an environmental impact statement.

The BIA has contracted with public and private groups for water quality assessments of Indian reservations. These assessments were made from existing data on surface and groundwater and were used as inputs into the BIA's environmental impact statements for coal leasing and related energy development on both the Northern Cheyenne and Crow Indian Reservations. The U. S. Department of Agriculture through the Surface Environment and Mining (SEAM) Program is also involved in water quality related studies within the area. In addition, the National Commission on Water Quality has selected a reach of the Yellowstone River for detailed studies and mathematical modeling. The USGS is a contractual agency. Many of the agencies listed previously have contracts with the USGS for the collection of data on surface water discharge and/or surface and groundwater quality.

The Water Resources Division of the Montana State Department of Natural Resources is currently developing a water framework plan for Montana. The Middle Yellowstone Basin will be included as part of this plan. They have contracted with the USGS for water discharge monitoring. Several of these sites are within the Middle Yellowstone Basin.

The Montana State Bureau of Mines and Geology is conducting groundwater studies in the immediate Colstrip area of the basin. Extensive sampling of wells and springs and of the base flow of Armells and Sarpy Creeks also has been undertaken. The Montana State Department of Lands has initiated a study of saline seep problems in Montana.

The University of Montana at Missoula has proposed as a part of their National Science Foundation, RANN grant application (Research Applied to National Needs) a water resources study which would include, in part, the Middle Yellowstone Basin. This is in addition to their commitments with the NGPRP and the Energy Planning Division of the Montana State Department of Natural Resources and Conservation. Montana State University at Bozeman is also involved in water quality related studies in that portion of the basin around Colstrip.

Water quality monitoring is also being conducted by various private industries with operations in the Middle Yellowstone Basin. Westmoreland Resources, a division of Morrison-Knutson Construction Company; Western Energy, a subsidiary of the Montana Power Company; Decker Coal Company, a subsidiary of Peter Kiewit and Sons Construction Company, Mining Division; and Peabody Coal Company, a subsidiary of Kennecott Copper Corporation are the four companies currently strip mining coal in the Middle Yellowstone River

Basin. They have contracted private firms for the testing of surface and groundwater quality in their specific areas.

BASIN-WIDE WASTE TREATMENT MANAGEMENT PLANS

The federal government established a grant program to municipalities processed through the Montana State Department of Health and Environmental Sciences. This grant program provided the municipality with a percentage of the construction costs needed to update or establish a community sewage treatment facility including outfall and interceptor sewers. Priorities for these grants were established by the Montana State Department of Health and Environmental Sciences using an allocation formula which follows federal guidelines. The Community of Crow Agency is the only municipality in the Middle Yellowstone River Basin receiving a grant under this program. Any construction grant for sewage treatment facilities awarded after July 1, 1974, will come under the new federal grant program, Section 201 of the 1972 Amendment to the Federal Water Pollution Control Act. This requires that a municipality first submit a facility plan. No municipality within the Middle Yellowstone River Basin has submitted such a plan. There have been no area-wide waste treatment management plans in the basin under Section 208 of the 1972 Amendment to the Act but such plans are anticipated within the next several years.

At the present time several communities on the Crow and Northern Cheyenne Indian Reservations have received construction grants from the Public Health Service under PL 86-121 for water and sewer facilities. These monies are being administered by the Indian Health Service. In several of these communities and others which overlap reservation boundaries or are municipalities on deeded land adjacent to Indian housing developments, a coordinated effort has been initiated by the Montana State Department of Health and Environmental Sciences and the Indian Health Service to serve the entire community by a single water and a single sewer facility.

III. BASIN PHYSICAL CHARACTERISTICS

The Middle Yellowstone Basin (Plate I and Figure I) is on the western edge of the Great Plains. The basin is generally an area of rolling hills with gentle to moderate relief. The Bighorn Mountains spread into the southwest portion of the basin giving that area a steep mountainous character. There are two portions of the Custer National Forest within the basin. Both of these areas are of moderate mountain terrain with numerous rimrocks and springs. Most of these springs seep into the ground before reaching perennial streams. There are two Indian reservations within the basin, the Crow Indian Reservation and the Northern Cheyenne Indian Reservation. The Middle Yellowstone Basin includes the following Montana counties in the approximate percentages listed:

Carbon County - 20%
Yellowstone County - 67%
Treasure County - 100%
Garfield County - 2%
Powder River County - 30%
Big Horn County - 100%
Musselshell County - 5%
Rosebud County - 80%
Custer County - 35%

The basin has a total land area of about 10,600 square miles.

The Middle Yellowstone Basin includes the Yellowstone River and all its tributaries from the confluence of Pryor Creek at Huntley to the confluence of the Tongue River at Miles City (Figure I and Plate I). The two major tribuaries to the Yellowstone River in this reach are the Bighorn and Tongue Rivers. The flow of both of these streams is regulated by reservoirs in their upper drainage areas. Reservoirs in Montana are Yellowtail on the Bighorn River and the Tongue River Irrigation Reservoir on the Tongue River. Yellowtail extends into Wyoming (Ref. 16, 19). The only other reservoir of any size, i.e., serving more than just stock watering or occasional flood irrigating, is the Lodge Grass Storage Reservoir on Willow Creek, which is a tributary of Lodge Grass Creek. This reservoir is on the Crow Indian Reservation. There are six municipal waste dischargers in the basin which are under or liable to be under state discharge permits. Thirteen municipal discharges within the basin are not under or liable to be under state discharge permits. Five of these are communities on Indian reservations, four are federal installations, and the remaining are non-discharging facilities. The nine federal dischargers are under or liable to be under federal waste discharge permits. There are five industrial discharges within the basin which are under or liable to be under state permits, and one fish hatchery liable to be under a federal waste discharge permit.

There are 45 water quality sampling sites set up in the basin to obtain needed water quality data for the Middle Yellowstone Water Quality Management Plan. The USGS (U. S. Geological Survey) is monitoring 23 sites for flow within the basin and two more sites which border the basin and thus have applicable data. Of these 25 sites 16 are also monitored for water quality. Thirty additional water quality sampling sites were set up by the Montana Water Quality Bureau as a result of the Colstrip generating plants study for the Energy Planning Division of the Montana State Department of Natural Resources.

All surface waters within the Middle Yellowstone Basin have been classified by the State of Montana. The entire Yellowstone River mainstem within the reach of the Middle Yellowstone Basin and all its tributaries with the exception of those listed below have been designated B-D_3. The Pryor Creek drainage; the Bighorn River drainage above, but excluding, Williams Coulee near Hardin; and the Little Bighorn River drainage above and including Lodge Grass Creek near Lodge Grass have been designated B-D_1. The remainder of the Little Bighorn drainage; the remainder of the Bighorn River drainage; and the Tongue River mainstem from the Tongue River Irrigation Reservoir to, but excluding, Prairie Dog Coulee have been classified B-D_2. These classifications designate that the quality of the water is to be maintained suitable for drinking; culinary and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary to remove naturally present impurities; and bathing, swimming and recreation. A B-D_1 further designates that the water be maintained for the growth and propagation of salmonid fishes and associated aquatic life, water fowl and furbearers. A B-D_2 designates that the water be maintained suitable for the growth and a marginal propagation of salmonid fishes and associated aquatic life, water fowl and furbearers. A B-D_3 classification designates that the water be maintained for growth and propagation of nonsalmonid fishes and associated aquatic life, water fowl and furbearers. The detailed criteria for B-D_1, B-D_2, and B-D_3 classifications are given in Montana's Water Quality Criteria, Water Use Classifications and Policy Statements (Appendix B).

The entire Middle Yellowstone Basin is designated as one segment by the State of Montana and has been classified as an effluent limited class segment. This classification indicates that water quality in the segment is meeting and will continue to meet applicable water quality standards after application of effluent limitiations required by the Federal Water Pollution Control Act Amendment of 1972.

Table 1 is a list of the perennial streams or streams with sufficient drainage area to warrant a sampling site in the Middle Yellowstone Basin. Also, included in Table 1 is the Montana State Department of Natural Resources and Conservation (DNRC) sub-basin designation, the drainage area of these sub-basins, and receiving waters of the streams.

CLIMATE

The mountains to the west and southwest of the Middle Yellowstone Basin create a moisture shadow. Air masses moving toward the basin from these directions must rise to get over the mountains and thus lose most of their moisture before reaching the basin. In these mountains sufficient amounts of snow usually accumulate during the winter and give rise to distinct runoff periods. Average annual precipitation for the area ranges from 11 to 16 inches. The maximum amount of precipitation usually occurs during late spring and early summer with the minimum amount being in late fall and winter. About 70 percent of the precipitation falls during the April through September period, the growing season, which permits extensive dryland farming. Table 2 shows the mean monthly precipitation in inches, the mean annual precipitation in inches, and the period of record in years for weather stations in the Middle Yellowstone Basin. Figure 2 compares graphically the mean monthly precipitation of several weather stations listed in Table 2 (Ref. 22). Table 3 shows the mean daily maximum and minimum temperatures in °F by month and the period of record in years for weather stations in the Middle Yellowstone Basin (Ref. 22). Figure 3 compares graphically the mean daily maximum and minimum temperatures of several weather stations listed in Table 3.

SOILS

Soil groups most widely represented in the Middle Yellowstone River Basin in Montana are those developed on alluvial fans, stream terraces, and flood plains; those developed on undulating to hilly sedimentary plains; those developed on dissected and rough broken uplands; and those developed on smooth uplands.

Soils on alluvial fans, stream terraces, and flood plains are nearly level to sloping, deep soils dominated by fine sandy loams, silt loams, and silty clay loams. These soils generally have medium runoff and present a moderate erosion hazard. Some of these soils, particularly on flood plains, are somewhat poorly drained and have a high salt content.

Soils on undulating to hilly sedimentary plains are deep to shallow loams, silt loams, silty clay loams and sandy loams

Table 1

Streams Sampled in the Middle Yellowstone Basin

STREAM	DNRC SUB-BASIN DESIGNATION	DRAINAGE AREA IN SQUARE MILES	RECEIVING WATERS
Arrow Creek	43Q		Yellowstone River
Fly Creek	43Q		Yellowstone River
Yellowstone River from confluence of Pryor Creek to confluence of Bighorn River	43Q	1520	
Sage Creek	43N	210	Shoshone River
E Fork of Pryor Creek	43E		Pryor Creek
Hay Creek	43E		Pryor Creek
Pryor Creek	43E	610	Yellowstone River
Porcupine Creek	43P		Bighorn River
Dry Head Creek	43P		Bighorn River
Hoodoo Creek	43P		Bighorn River
Big Bull Elk Creek	43P		Bighorn River
Little Bull Elk Creek	43P		Bighorn River
Black Canyon Creek	43P		Bighorn River
Soap Creek	43P		Bighorn River
Rotten Grass Creek	43P		Bighorn River
Beauvais Creek	43P		Bighorn River
Tullock Creek	43P		Bighorn River
Bighorn River	43P	2380	Yellowstone River
Pass Creek	43O		Little Bighorn River
Owl Creek	43O		Little Bighorn River
Lodge Grass Creek	43O		Little Bighorn River
Grey Blanket Creek	43Q		Little Bighorn River
Reno Creek	43O		Little Bighorn River
Little Bighorn River	43O	1030	Bighorn River
Froze-to-Death Creek	42KJ		Yellowstone River
Sarpy Creek	42KJ		Yellowstone River

Table 1
(continued)

STREAM	DNRC SUB-BASIN DESIGNATION	DRAINAGE AREA IN SQUARE MILES	RECEIVING WATERS
Great Porcupine Creek	42KJ		Yellowstone River
Reservation Creek	42KJ		Yellowstone River
Armells Creek	42KJ		Yellowstone River
Smith Creek	42KJ		Yellowstone River
Little Porcupine Creek	42KJ		Yellowstone River
Sweeny Creek	42KJ		Yellowstone River
Moon Creek	42KJ		Yellowstone River
Yellowstone River from confluence of Bighorn River to confluence of Tongue River	42KJ	4060	
Indian Creek	42A		Rosebud Creek
Davis Creek	42A		Rosebud Creek
Muddy Creek	42A		Rosebud Creek
Lame Deer Creek	42A		Rosebud Creek
Rosebud Creek	42A	1270	Yellowstone River
Youngs Creek	42B		Tongue River
Squirrel Creek	42B		Tongue River
Deer Creek	42B		Tongue River
Stroud Creek	42B		Tongue River
Hanging Woman Creek	42B		Tongue River
Tongue River from state line to confluence of Hanging Woman Creek	42B	840	
Logging Creek	42C		Tongue River
Otter Creek	42C		Tongue River
Little Pumpkin Creek	42C		Pumpkin Creek
Pumpkin Creek	42C		Tongue River
Tongue River from confluence of Hanging Woman Creek to confluence of Yellowstone River	42C	2800	Yellowstone River

Table 2
Mean Monthly Precipitation in Inches for
Weather Stations in the Middle Yellowstone Basin (Ref. 22)

Station	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	Mean Annual	Period Record
Billings	0.54	0.60	1.05	1.31	1.88	2.55	0.90	0.90	1.19	1.09	0.63	0.59	13.23	26 yea
Broadview	0.55	0.60	0.91	0.85	2.76	2.11	0.59	1.32	0.65	0.99	0.79	0.42	13.54	8 yea
Huntley	0.38	0.45	0.77	1.06	1.77	2.47	0.75	0.86	1.04	0.93	0.51	0.47	11.46	30 yea
Pryor	0.42	0.56	0.75	2.06	2.36	1.98	0.74	1.13	0.82	1.14	0.85	0.38	13.19	10 yea
Nyola	0.66	0.67	1.14	1.87	2.40	2.26	0.93	0.78	1.25	1.25	0.81	0.65	14.67	27 yea
Crow Agency	0.75	0.64	1.04	1.50	2.26	2.53	1.17	0.89	1.22	1.27	0.82	0.74	14.83	77 yea
Hardin	0.46	0.41	0.65	1.10	1.65	2.74	0.86	0.99	1.29	0.80	0.55	0.51	12.01	19 yea
Ballantine	0.42	0.48	0.80	1.01	1.68	2.53	0.84	0.89	1.04	0.89	0.52	0.48	11.58	41 yea
Hysham	0.33	0.44	0.74	1.03	1.66	2.49	0.98	0.99	0.84	0.88	0.52	0.42	11.32	15 yea
Busby	0.54	0.39	0.66	1.16	2.10	2.38	1.28	1.05	1.24	1.00	0.58	0.51	12.89	56 yea
Lame Deer	0.65	0.57	0.94	1.41	2.41	3.44	1.41	1.11	1.11	1.19	0.87	0.72	15.83	22 yea
Colstrip	0.57	0.58	1.01	1.63	2.22	2.83	1.28	1.23	1.15	1.21	0.68	0.58	14.97	32 yea
Forsyth	0.41	0.37	0.59	0.88	2.13	2.86	1.32	0.89	1.04	0.86	0.50	0.32	12.17	32 yea
Miles City FAA	0.41	0.40	0.60	1.03	1.93	3.10	1.41	1.28	1.06	0.90	0.44	0.33	12.89	23 yea
Volborg	0.32	0.41	0.45	1.14	2.22	2.37	1.64	1.60	0.74	0.78	0.48	0.37	12.52	10 yea
Birney	0.14	0.43	0.29	1.30	1.93	2.57	1.10	1.05	0.43	0.94	0.87	0.39	11.44	6 yea
Basin Mean	0.47	0.53	0.77	1.33	2.08	2.58	1.08	1.06	1.01	1.01	0.65	0.49	13.03	
Basin Range	0.14	0.37	0.29	0.88	1.65	1.98	0.59	0.78	0.43	0.78	0.44	0.32	11.32	
	0.75	0.67	1.14	2.06	2.76	3.44	1.64	1.60	1.29	1.27	0.87	0.74	15.83	

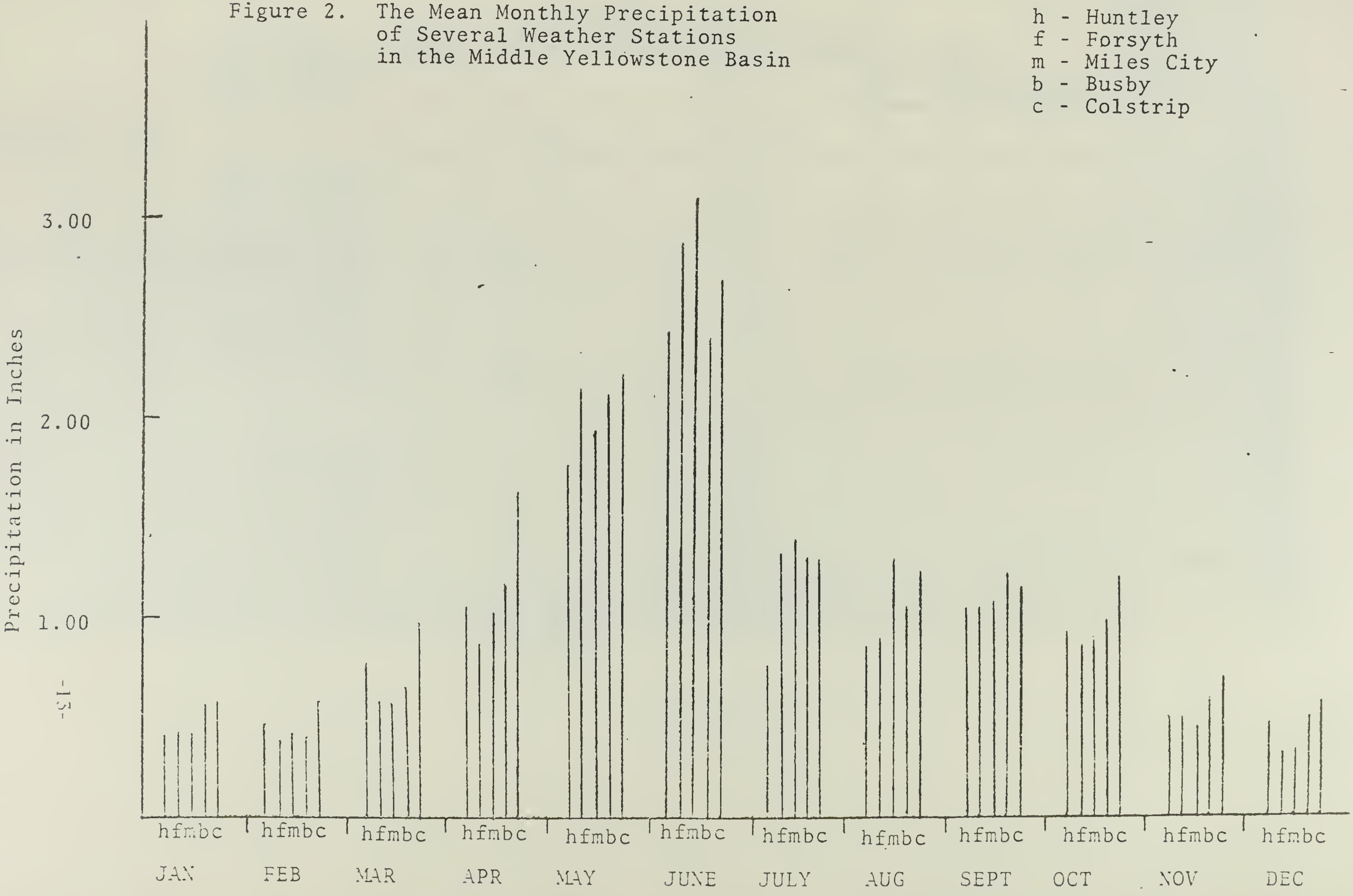

Figure 2. The Mean Monthly Precipitation of Several Weather Stations in the Middle Yellowstone Basin

TABLE 3

Mean Daily Maximum and Minimum Temperatures in °F by Month
for Weather Stations in the Middle Yellowstone Basin (Ref. 22)

Weather Station	JAN		FEB		MAR		APR		MAY		JUNE		JULY		AUG		SEPT		OCT		NOV		DEC		Period of Record
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	
Ballantine	34.0	9.1	39.7	12.9	48.2	21.4	61.8	31.3	72.4	41.5	79.6	49.5	90.4	55.4	88.0	52.9	76.7	42.7	64.4	32.9	47.2	22.0	37.9	13.8	41 years
Billings	32.7	13.3	35.9	15.8	43.6	23.1	57.5	33.2	68.1	43.7	75.3	50.9	87.4	58.6	85.1	56.5	73.8	47.3	61.8	35.1	45.2	26.3	35.5	[illegible]	[illegible]
Busby	31.8	3.2	35.8	6.6	45.0	17.4	55.9	29.1	68.2	38.2	77.6	46.5	88.4	51.9	86.9	49.5	75.4	39.8	62.4	29.6	46.6	18.5	[illegible]	[illegible]	54 years
Colstrip	34.6	8.5	37.5	11.8	45.5	19.8	59.4	30.2	70.3	39.7	78.5	48.3	90.2	54.9	88.5	52.5	77.1	42.6	64.6	32.6	47.2	21.5	39.1	14.2	[illegible] years
Crow Agency	32.7	5.8	36.3	9.2	46.9	20.4	61.1	31.5	69.9	40.8	80.4	49.1	90.5	54.4	87.5	51.0	76.3	41.5	64.0	31.8	47.6	19.9	[illegible]	11.8	[illegible] years
Forsyth	29.8	5.1	35.0	9.9	45.0	19.7	61.8	32.3	70.3	42.1	78.0	50.7	89.0	57.1	87.9	54.6	76.2	44.8	65.7	33.5	46.7	21.5	36.9	12.6	29 years
Hardin	33.1	5.5	38.4	11.0	46.2	19.1	62.1	30.6	71.3	41.0	78.1	48.6	89.7	53.9	88.1	51.8	76.3	42.0	65.0	31.5	47.7	20.3	37.2	11.8	18 years
Huntley	31.9	7.1	35.0	10.4	45.0	20.3	57.5	30.7	67.7	40.9	74.6	48.9	85.3	54.3	85.2	51.5	72.0	42.5	60.9	32.7	45.1	21.0	36.8	13.1	[illegible] years
Hysham	31.6	5.4	37.5	10.2	45.8	17.8	61.6	30.2	72.0	40.7	79.3	49.1	90.5	55.0	89.3	52.1	77.5	42.0	65.2	31.6	47.2	20.1	38.9	[illegible]	[illegible] years
Lame Deer	33.9	7.1	39.5	9.9	45.6	17.9	60.8	29.1	70.0	38.4	77.6	46.0	89.1	51.3	88.7	49.0	77.4	39.9	65.7	30.6	47.2	19.2	40.8	12.5	21 years
Miles City	27.5	5.6	31.4	8.3	42.0	19.1	58.5	32.9	69.9	43.8	77.1	51.9	89.3	59.7	87.5	57.6	75.1	46.8	67.7	35.8	43.0	21.4	34.2	15.3	25 years
Wyola	36.5	8.3	39.2	10.8	45.4	18.8	59.4	29.7	68.8	38.8	77.2	46.0	89.2	51.3	87.8	48.7	76.1	39.9	64.8	31.5	48.5	20.0	41.2	13.8	26 years
Basin	27.5	3.2	31.4	8.3	42.0	17.4	57.5	29.1	67.7	38.2	94.6	46.0	85.3	51.3	83.2	48.7	72.0	39.8	60.9	30.6	43.0	18.5	34.2	8.3	
Range	36.5	13.3	39.7	15.8	46.9	23.1	62.1	33.9	72.4	43.8	80.4	51.9	90.5	58.6	89.3	57.6	77.4	47.3	67.7	38.1	48.5	26.3	41.2	20.3	
Basin Mean	32.7	7.0	36.8	10.6	45.2	19.6	60.0	31.0	69.9	40.8	77.8	48.8	89.1	54.8	87.4	52.4	75.8	42.6	63.8	32.7	46.6	21.0	38.0	13.2	

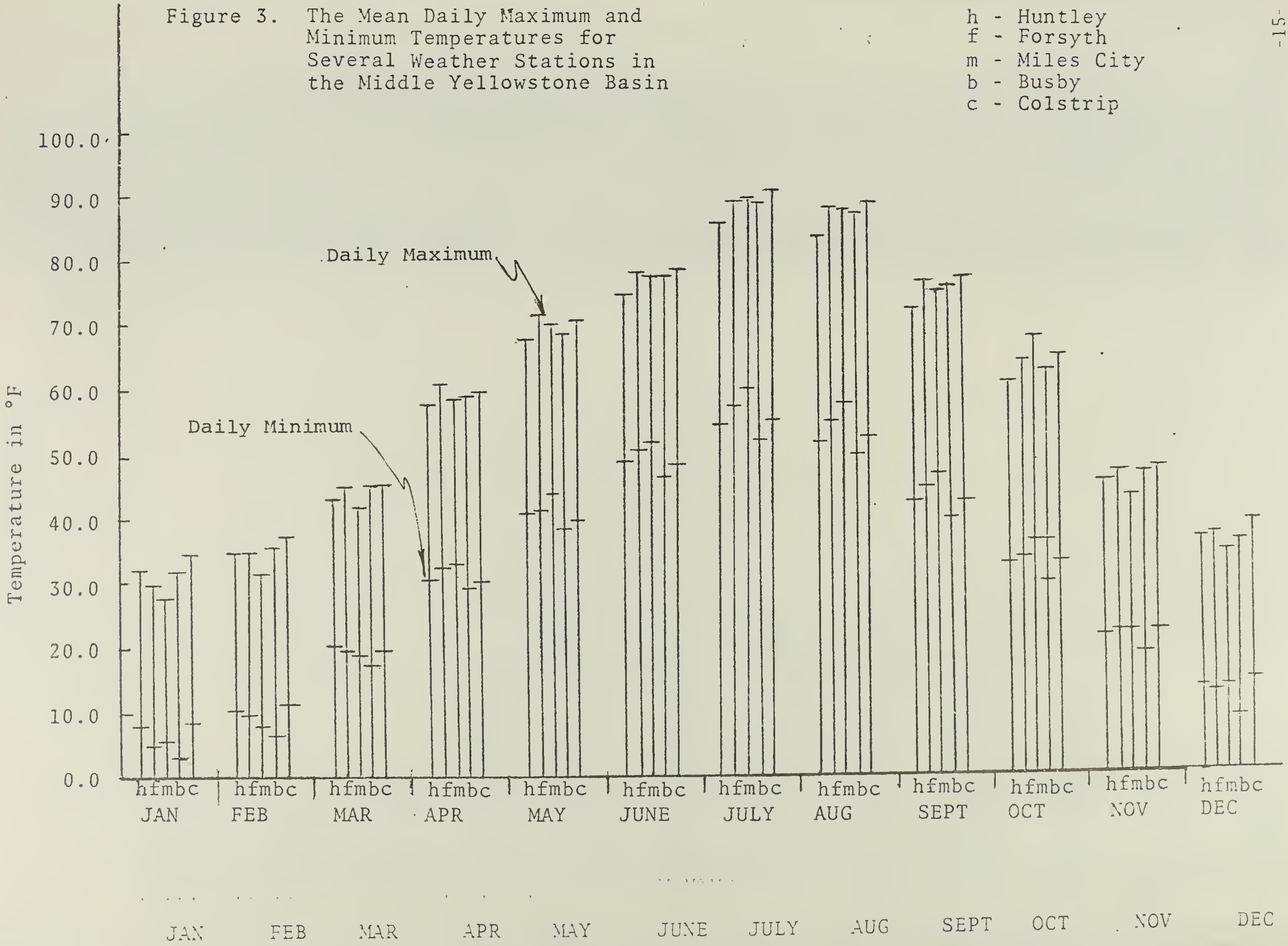

Figure 3. The Mean Daily Maximum and Minimum Temperatures for Several Weather Stations in the Middle Yellowstone Basin

underlain by siltstones or weakly consolidated sandstones. These soils have slow to medium runoff and present slight to moderate erosion hazards.

Soils on the dissected sedimentary plains and rough broken uplands are generally moderately deep to shallow on hilly to very steep slopes. There are steep buttes that have shale exposed and broken slopes with steep drainageways, ridges, and knobs. The soils are drained by branching drainageways that commonly are gullied at the headwaters. These soils are generally clays to silty clay loams. They have rapid runoff and present severe erosion conditions and have a high potential as a sediment salt source to streams.

Soils of the smooth to rolling uplands are nearly level to rolling, deep loams and clay loams underlain by silty clay loam alluvium on sands and gravels. They would present a slight to moderate hazard.

Soils in the Middle Yellowstone Basin are used for dryland and irrigated crops and range. Soils on flood plains, low terraces, fans and footslopes are used for dryland crops with suitable areas under irrigation. Soils on uplands are used mainly for range with some gently to moderately sloping soils used for dryland crops.

LAND USE

There are about 9,836,160 acres within the Middle Yellowstone River Planning Unit. The entire Northern Cheyenne (444,277 acres) and Crow Indian (2,283,000 acres) Reservations lie within the unit. The Bureau of Land Management administers the Pryor Mountain Wild Horse Range in southeastern Carbon County. The Bureau of Sport Fisheries and Wildlife maintains the Fort Keogh National Bird Refuge (44,000 acres) located at the junction of the Yellowstone and Tongue Rivers. The Bighorn Canyon National Recreation Area (63,277 acres), administered by the National Park Service, surrounds Bighorn Reservoir.

Of the 10,650,000 tons of coal mined in Montana in 1973, 97% came from the Middle Yellowstone River Planning Unit. This area contains a large percentage of the Fort Union strippable coal deposits in Montana. Crude oil production is about 1,071,500 barrels per year while gas production is negligible.

About 75% of the planning unit lands are used for pasture and range in the production of livestock. Hay, pasture, and sugar beets comprise about 70% of the irrigated lands. Wheat, oats, and barley are the primary dryland farmed crops.

Small water areas (ponds 2-40 acres in size) make up less than 1% of the area, while forests occupy about 7%. Lumber production amounts to about 1.5 million board feet per year.

Miles City (population 9,073), Hardin (population 2,733), and Forsyth (population 1,073) are the major population and trade centers.

WATER USE

Irrigated agriculture is the primary water user. The 237,963 acres of irrigated lands deplete about 654,400 acre-feet of water per year from the Yellowstone River system.

Major Montana State Water Conservation Board projects in the area are Hysham Bench Unit and the Tongue River Reservoir. These two projects deliver supplemental water to about 20,000 acres of irrigated land. The Hysham Bench project is located south of the Yellowstone River near Hysham. The Tongue River Reservoir is located about ten miles north of the Montana-Wyoming border near the Town of Decker. The reservoir has a capacity of 69,439 acre-feet with 35,835 acre-feet contracted to agriculture and 4,175 acre-feet optioned for industrial use.

The Bureau of Reclamation has constructed the Huntley Irrigation Project and Yellowtail Dam. The Huntley project serves about 24,000 acres of land that lie along the Yellowstone River below the Town of Huntley. Yellowtail Dam backs up Bighorn Reservoir. The dam houses four 62.5 megawatt generating units that produce an average of one billion kilowatt-hours of energy annually. Water from Bighorn Reservoir was planned to irrigate 43,550 acres of land in the Hardin Unit, however, no land has yet been irrigated with this water. The reservoir provides recreational opportunities for fishing, camping, boating, and bird and wildlife watching.

About 700,000 acre-feet of water has been optioned for industrial use. The Crow Irrigation Project (Bureau of Indian Affairs) provides water for about 30,000 acres of land on the Crow Indian Reservation. The remainder of irrigated lands has been developed by individuals and irrigation districts.

There are 11 towns that use about 3,534 acre-feet of municipal water per year from public water systems. About 85% of the municipal water is derived from surface water. Rural water supplies are largely groundwater. Industrial water use in negligible.

POPULATION AND ECONOMICS

For this profile, 1970 census data from county census divisions have been summarized to approximate the actual basin figures. This gives a county-by-county share of people and jobs as of 1970. This share was then applied to historical data and county projects to yield the basin table. Because coal development is such an important factor in the basin's economic future, a special set of projects have been included which consider coal-related population and employment.

Historically agriculture has been the predominant economic activity in the basin. Irrigation is mainly restricted to the river valleys with hay, corn for silage, and sugar beets being the major crops. Out of the river valleys, the major land use is livestock grazing, with extensive dryland grain production in some areas. On the average, the marketing receipts from livestock are twice those from crops in counties in the basin. Although Billings is outside the basin boundary, it is the wholesale center for the entire region, and also captures a significant portion of the retail trade. Billings is the largest city in Montana. The basin includes all of two Indian reservations, the Crow and the Northern Cheyenne.

Communities in the Middle Yellowstone Basin with 100 or more people are listed below along with their 1970 population.

COMMUNITY	COUNTY	1970 POPULATION
Busby	Big Horn	300
Crow Agency	Big Horn	1,000
Fort Smith	Big Horn	125
Garryowen	Big Horn	361
Hardin	Big Horn	2,733
Lodge Grass	Big Horn	806
St. Xavier	Big Horn	100
Wyola	Big Horn	125
Ashland	Rosebud	531
Colstrip	Rosebud	200
Forsyth	Rosebud	1,873
Lame Deer	Rosebud	650
Rosebud	Rosebud	225

Table 4

Population and Employment, Historical and Projected

1930-1985

YEAR	1930	1940	1950	1960	1970	1980	1985
Population	20,085	21,200	21,103	21,714	21,694	22,092[1] 26,542[2]	22,238[1] 26,688[2]
Employment Total	7,298	6,628	7,126	6,989	7,529	7,620[1] 9,160[2]	7,722[1] 9,262[2]
Agriculture	4,604	3,571	3,156	2,309	1,766		
Forestry & Fisheries	19	9	8	9	11		
Mining	196	92	134	61	107		
Construction	169	309	422	356	414		
Manufacturing	216	195	222	372	617		
Services & Other	2,094	2,452	3,184	3,882	4,614		

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[1] Strictly historical projection. No inclusion of coal impact.

[2] Projection [1] (above) plus coal impact. Includes 4,450 people and 1,540 jobs. This assumes that 47% of the impact will occur in Billings. It includes three major coal mines with Montana impacts and four generating units at Colstrip. Construction is assumed completed by 1980 (Ref 55)

COMMUNITY	COUNTY	1970 POPULATION
Hysham	Treasure	350
Ballantine	Yellowstone	350
Custer	Yellowstone	300
Huntley	Yellowstone	400
Shepherd	Yellowstone	200
Worden	Yellowstone	425

Without question, the most important factor currently looming in the basin's economic future is coal. Mines are currently operating at Colstrip (Western Energy and Peabody), Decker (Decker Coal Company), and Sarpy Creek (Westmoreland). Two coal-fired electrical generation units are under construction at Colstrip with two more proposed. The greatest short-term impact on population and employment will be from construction, although a significant number are expected to remain permanently to run the mines and the power plants. Because of the proximity to Billings to the coal fields, it is uncertain how many temporary and permanent residents will reside near the job site and how many will reside in Billings.

Table 4 summarizes historical population and employment from 1930 to 1970. Two projections to 1980 and 1985 have been included. The first is a standard historically-based projection which does not include coal development. The second includes primary and derivative jobs and population based on a State Employment Service study. It is important to note that many energy firms have voiced interest in mining and processing coal from the Middle Yellowstone area. If their plans materialize, the resultant impact could conceivably be much greater than has been shown. This is particularly true regarding construction employment, which is very changeable on quite short notice.

HYDROGEOLOGY

Groundwater is widely used in the Middle Yellowstone River Basin for domestic, stock, municipal, industrial, and irrigation purposes. The predominant use of groundwater in the basin is for private water and stockwater wells. Groundwater is widely used source of water and is a valuable resource in the basin. There are a large number of technical reports that describe groundwater in portions of the basin, and numerous detailed groundwater investigations have been conducted and are presently being conducted, particularly in coal development areas of the basin.

The occurrence, availability, and quality of groundwater in the basin is dependent on geological conditions. The basin has a complex geological history, and as a result, geological conditions in the area are variable and complicated. The geological history includes long periods of sedimentation interrupted by period uplift and erosion. At the end of Mesozoic time (65 million years ago) a period of uplift, folding and faulting occurred. Sediments in the basin were eroded, and thick layers of rocks were removed. It was during this geological period that mountainous portions of the basin, including the Big Horn and Pryor Mountains, were formed. Geological units of importance to groundwater resources in the Middle Yellowstone Basin include bedrock formations of Cenozoic and Mesozoic age, bedrock formations of Tertiary age, and alluvial deposits of Pleistocene and Quaternary age. Basin geological formations have been significantly influenced by structural deformation, including uplift and faulting south of Hardin, and in the Powder River Basin south of Ashland, the Bull Mountain Basin north of Huntley, and the Porcupine Dome north of Forsyth.

Bedrock formations of the Paleozoic Era (230 to 500 million years old) are present in the southwest corner of the basin in the Big Horn Mountains. There has not been extensive development of water-bearing formations in this area; however, a number of formations of Paleozoic age contain groundwater. Generally, water-bearing formations in this area will yield moderate quantities of fair quality water. The Madison Formation, present in this area, generally will yield moderate to very large quantities of fair to good water to wells.

Bedrock formations of Mesozoic age particularily the Cretaceous Period, outcrop extensively in the southwest and north-central portions of the basin. Some of these formations will yield moderate quantities of fair quality waters to wells. Of particular interest are widespread sandstone formations, including the Hell Creek Formation, Fox Hills Formation, Judith River Formation, and Eagle Sandstone. These units are widely used as a groundwater source in this area and usually will yield small to moderate quantities of fair quality waters to wells.

Much of the southern, southeastern, and northeastern portions of the basin are overlain by the Fort Union Formation of Tertiary age (1-65 million years old). The Fort Union Formation, where uninfluenced by erosion, consists of about 2,400 feet of clay, shale, lignite coal, sandy shale, and sandstone beds. In much of the area, erosion has significantly reduced the thickness of the Fort Union Formation. The Fort Union Formation generally consists of an upper member termed the Tongue River Member, which is a good water-bearing aquifer where it is present in sufficient thickness. Underlying the Tongue River Member is the Lebo Member, which consists of about 200 to 300 feet of essentially nonwater-bearing shales and shaly sandstones. Beneath the Lebo Member is the Tullock Member, which consists of about 375 feet of shale and sandstone and yields small to moderate quantities of fair quality water to wells. The Fort Union Formation is the dominant geologic formation for coal development in the basin. Extensive beds of lignite and subbituminous coal are present in this formation. Coal beds commonly act as aquifers in the basin and in some cases coal beds are the better aquifers in the formation. Typically, coal beds that are water bearing will yield small to moderate quantities of fair quality water.

The Wasach Formation, of Tertiary age, consisting of about 350 feet of clay, sandstone, and shale, is present in the southeastern corner of Big Horn County. The Wasach will yield small quantities of fair to poor quality water.

Continental glaciation did not reach southward into the Middle Yellowstone Basin; however, there are alluvial and terrace deposits of Pleistocene and Quaternary age present along major stream drainages of the basin. These deposits generally are thin to moderately thick and will yield small to large quantities of fair to poor quality waters. Generally, terrace deposits along the Yellowstone River are moderately thick and will yield large quantities of fair quality water.

Pollution of groundwater has occurred in a number of areas in the Middle Yellowstone River Basin. Strip mines at Colstrip, Decker, and Sarpy Creek are under active investigation to determine the impact of these strip mines on groundwater. Preliminary information indicates that leachates from mine spoils have degraded groundwater quality in the vicinity of the mining operations.

Several saline seep areas have been identified within the basin along the Yellowstone River downstream from Huntley. The characteristics of saline seep areas are not well known at this time, and studies are presently underway to determine the extent and magnitude of saline seeps in the basin.

Sewage stabilization lagoons generally have seepage into the groundwater and create localized areas of groundwater pollution. However, there have been no problems due to lagoon seepage reported in the basin. There are 19 sewage lagoons in the basin.

Septic tank and subsurface disposal can create localized areas of groundwater pollution. Where there are large numbers of septic tanks and individual water supplies using wells, groundwater pollution can lead to public health problems if the wells and septic tank systems are improperly designed and located. Although there are areas that have septic tanks and wells, there have been no specific problems identified in the basin; however, the character of this potential groundwater pollution problem has not been thoroughly investigated.

There are a number of feedlots in the Middle Yellowstone Basin, particularly along the Yellowstone River. Feedlots have been identified in a number of past studies as contributors of pollution to groundwater due to seepage of water from feedlots downward to the groundwater system. There have been no specific problems identified in the basin associated with feedlots. Future groundwater quality work within the basin will assess the impact of feedlots on groundwater.

IV. MONTANA WATER POLLUTION CONTROL PROGRAM

INTRODUCTION

Water quality management planning is part of a broad, comprehensive water pollution control program administered by the Water Quality Bureau of the Environmental Sciences Division of the Montana Department of Health and Environmental Sciences. Details of this program are described in annual reports of the bureau. Important elements of the state program are:

1. State and federal waste discharge permit programs.
2. Water quality standards.
3. Statewide monitoring and surveillance.
4. Facilities construction grants, plan review, operation and maintenance inspections, training and licensing of operators.
5. Public participation.
6. Enforcement.

STATE AND FEDERAL WASTE DISCHARGE PERMIT PROGRAMS

The present state program of issuing waste discharge permits is operated under the authority given by the Montana water pollution control law and the Montana Pollutant Discharge Elimination System (MPDES). At the present time, the U. S. Environmental Protection Agency (EPA) is also issuing waste discharge permits in the state of Montana to federal facilities and to discharges, from other than incorporated communities, on Indian reservations. The permits are being issued pursuant to the National Pollutant Discharge Elimination System (NPDES) created by the Federal Water Pollution Control Act Amendments of 1972 (FWPCAA of 1972). To eliminate the duplication of effort which formerly existed, the state of Montana applied for and received authority from EPA to issue NPDES permits in Montana. Section 402

of the FWPCAA of 1972 provides that states with adequate water pollution control programs may apply for and receive authority from EPA to issue discharge permits under the NPDES in their own states. Montana made the necessary revisions to the state water pollution control laws during the 1973 legislative session to provide statutory authority for administration of the NPDES program in Montana. The Montana Department of Health and Environmental Sciences was given the authority to administer the waste discharge permit program on June 10, 1974. Waste discharge permits issued under the NPDES prior to the MPDES permit program will serve as MPDES permit until their date of expiration. All MPDES permits issued meet the minimum requirements of the EPA for NPDES permits.

The Federal Water Pollution Control Act Amendments of 1972 established the following time schedule for upgrading waste treatment facilities:

MUNICIPALITIES

1. Secondary treatment by July 1, 1977.
2. Best practical control technology by July 1, 1983.
3. No discharge of pollutants by 1985 (goal)

INDUSTRIES

1. Best practicable control technology by July 1, 1977.
2. Best available control technology by July 1, 1983.
3. No discharge of pollutants by 1985 (goal).

NATIONAL SECONDARY TREATMENT REQUIREMENTS (FWPCAA OF 1972)

Minimum five-day biochemical oxygen demand (BOD5) reduction to 85 percent.

Minimum suspended solids reduction of 85 percent.

Maximum effluent BOD5 of 30 mg/l on monthly average and 45 mg/l on weekly average.

Maximum effluent suspended solids of 30 mg/l on monthly average and 45 mg/l on weekly average.

Maximum effluent fecal coliform of 200 organisms/100 ml on monthly average and 400 organisms/100 ml on weekly average.

pH limits on effluent maintained between 6 and 9.

Self-monitoring of these parameters is required. The frequency of monitoring is based on the population served and the complexity of the treatment facility and is stated in the NPDES or MPDES permit. In addition, some municipal dischargers are limited for and required to monitor effluent oil and grease.

WATER TREATMENT PLANT TREATMENT REQUIREMENTS

There are no parameters specified by the FWPCAA of 1972 to be monitored for water treatment plant discharges. The following requirements are being placed on NPDES permits issued in Montana:

1. No change in operating procedures will be allowed that would result in a less desirable discharge.

2. As soon as practicable but no later than July 1, 1977:

Total suspended solids (TSS)	<45 mg/l weekly average <30 mg/l monthly average
Total dissolved aluminum	1.0 mg/l monthly average <1.5 mg/l grab sample
pH	Maintained between 6.0 and 9.0

INDUSTRIAL BEST PRACTICABLE CONTROL TECHNOLOGY REQUIREMENTS (FWPCAA OF 1972)

Industrial waste dischargers will be required to provide the best practicable control technology currently available in treatment of their waste discharges. The parameters will be limited and monitored, and the frequency of monitoring will vary with the different types of industries. The specific parameters to be limited and monitored and the frequency of monitoring are stated in the NPDES or MPDES permit.

AGRICULTURAL TREATMENT REQUIREMENTS (FWPCAA OF 1972)

Federal regulations require that any animal confinement facility which on any 30 days during the previous twelve months contained 1,000 or more animal units must apply for a waste discharge permit. The Montana Pollutant Discharge Elimination System Rule requires that any animal confinement facility, without regard to size, which discharges to state waters must apply for a waste discharge permit. The following is a list of the number of animal units for those types of animal confinement facilities in or expected to be in operation in Montana:

Slaughter and Feeder Cattle	1.0 animal units/animal
Mature Dairy Cattle	1.4 animal units/animal
Swine over 55 pounds	0.4 animal units/animal
Sheep	0.1 animal units/animal
Fish (where discharge occurs on at least 30 days/year)	0.05 animal units/pound

The waste discharge permits issued for animal confinement facilities will generally prohibit any discharge of pollutants unless rainfall in excess of the 10-year/24-hour rainfall or equivalent moisture has been received.

Irrigation return flows will be subject to MPDES permit if there is a point source discharge through a man-made or man-maintained drainage system from 3,000 or more irrigated acres. The parameters to be monitored and the frequency of monitoring will be stated on the discharge permit.

WATER QUALITY STANDARDS

Water pollution control started in Montana in 1907 with passage of legislation designed to protect domestic water supplies. A more comprehensive law was passed in 1955 that dealt with control and protection of water for recreation, agriculture, and industry. The 1955 law also established a water pollution control council and charged it with the tasks of classifying all streams in the state according to their most beneficial uses and establishing water quality criteria for the streams. The 1955 law also involved upgrading the treatment of wastes going into the streams. Montana thus became one of the first states to have enforceable stream classifications.

In 1965, the U. S. Congress passed the Federal Water Quality Act which required that all states classify and establish water quality criteria for their interstate streams by July 1, 1967. Montana revised its standards for both interstate and intrastate waters and required a higher degree of stream quality than before. Secondary treatment or the equivalent was required of municipal and industrial discharges. In October, 1972, the Federal Water Pollution Control Act Amendments were passed expanding the authority of the Environmental Protection Agency. Uniform water quality standards and enforcement procedures throughout the United States became the objective. Montana revised its water quality standards and adopted these revised standards on July 13, 1973. The new standards became effective in November, 1973.

Montana water quality standards serve as a functional tool in protecting water quality; however, a number of laws, statutes, and regulations complement the water quality standards and significantly assist in protecting water quality.

STATEWIDE MONITORING AND SURVEILLANCE PROGRAM

Prior to 1972, Montana had done little water quality monitoring due to inadequate funding. With increased appropriations provided by the 1971 legislature and the federal government, the state greatly increased its effort. Personnel were added to the staff, and laboratory capabilities were expanded. The present state monitoring program includes compliance monitoring of point sources of wastes including monitoring of municipal and industrial wastes, long-term baseline monitoring of streams, and a statewide program for determining the general quality of all significant surface waters.

The statewide inventory of water quality will identify areas with water quality problems and will provide basic data for water quality management and planning programs. Included in the monitoring is a statewide assessment of the trophic (pollution level) status of Montana's lakes, reservoirs, and ponds. This program is coordinated with the EPA National Eutrophication Survey.

FACILITIES CONSTRUCTION, OPERATION, AND MAINTENANCE

A minimum requirement of primary treatment for all domestic sewage was first adopted by the Montana Board of Health in 1952. All of Montana's communities have met this requirement, and many of the communities are upgrading their facilities to secondary treatment or are in the process of constructing or planning secondary treatment systems. Since 1956, there has been a federal grant program to assist municipalities in the construction of sewage treatment facilities, including outfall and interceptor sewers. In 1971, the Montana state legislature appropriated $4,000,000 to aid municipalities in construction of these same facilities. The 1973 legislature appropriated $1,600,000 to reimburse municipalities that had proceeded with construction since July 1, 1966, without waiting for state grants. With passage of the Federal Water Pollution Control Act Amendments of 1972, 75 percent of eligible project costs are federally financed. Due to a shortage of federal grant funds, a priority system for allocation must be used. The state, under EPA guidance, establishes priorities for proposed waste treatment projects.

An important part of municipal sewage treatment is proper operation and maintenance of facilities after construction is completed. In an effort to improve operation and maintenance, the state has conducted an operators' school each year. During recent years, this school has had about 100 operators attending. In 1971, a grant was obtained from the federal government for employing two training instructors to establish training programs throughout the state. This activity is in addition to the annual school.

An operators certification program was established in 1968 following enactment of a law requiring certification of those responsible for the operation of sewage treatment or industrial waste treatment systems.

PUBLIC PARTICIPATION

Public participation in the water pollution control is an increasingly important aspect of the state program. Public hearings are held concerning proposed regulations, water quality management plans, and waste discharge permit applications. The state also has an environmental impact statement requirement. These statements are presented to the public for comment, and hearings are conducted on highly controversial issues.

The public also is kept informed by means of a water pollution control advisory council which has been established by law to assist the Water Quality Bureau in preparation of rules and regulations and dissemination of information to interested groups. Similarly, public meetings are attended on request, and a quarterly newsletter is published by the Water Quality Bureau.

ENFORCEMENT

Montana's laws on water pollution basically state (1) it is unlawful to cause pollution or place materials in a location where they are likely to cause pollution of state waters, and (2) discharge of waste material into state waters without a permit from the Department of Health and Environmental Sciences. Two administrative rules have been adopted by the Board of Health and Environmental Sciences which are the chief elements in Montana's water pollution control program. Montana's water quality standards serve as the primary means for defining pollution, and the Montana Pollutant Discharge Elimination System rule provides the mechanism for authorizing and controlling point source discharges to state waters. Violators of the law, a rule, permit, or order could be subject to injunction, civil penalties up to $10,000 for each day of violation, or criminal penalties with fines not to exceed $25,000 per day of violation and/or imprisonment for not more than one year for an initial conviction and not more than $50,000 per day of violation and/or imprisonment for not more than two years for subsequent violations. Significant steps were taken in 1974 to establish a workable enforcement program, including increasing the legal staff and additional allocation of technical staff.

V. WATER POLLUTION SOURCES

In the Middle Yellowstone Basin, water pollution may result from a number of activities, only a few of which are represented by point discharges. Most water quality problems in the basin are due to sedimentation from runoff of erodible soils. There are 19 municipal sewage treatment facilities in the basin with six of these designed on a non-discharge basis. Five potential industrial discharges exist within the basin. Characteristics of all known discharges, both municipal and industrial, are shown in Tables 5 and 6.

MUNICIPAL DISCHARGES

Assessments of community needs are based on the fact that the Middle Yellowstone Basin is an effluent limited segment. Presently, preliminary engineering reports do not exist for most communities discussed herein. Further assumptions are as follows:

A. Meeting secondary treatment requirements is considered satisfactory for effluent limited drainages.

B. Facilities should be designed and constructed to ensure that secondary treatment requirements will be met. In certain cases, properly designed and operated lagoon systems have been shown to meet effluent limitations. Therefore, to provide a basis for estimating costs associated with attaining secondary treatment, examples for each discharge were based upon a lagoon system having a minimum of three cells. The cells must be 1) adequately designed on both an organic and hydraulic basis, 2) amenable to series or parallel operation, and 3) provided with disinfection facilities. It must be realized that such systems may not provide satisfactory treatment in all cases, but cost estimates based on the above assumptions should be fairly realistic.

C. Organic loading was evaluated on the basis of 100 people per acre per day.

D. Hydraulic loading was evaluated on the basis of 100 gallons per person per day. The lagoon system should be capable of storing 180 days of flow (the winter flow) without discharge.

E. The cost of additional lagoon cells was based on $200 per acre of land and $2 per cubic yard for less than 75,000 cubic yards and $1 per cubic yard for more than 75,000 cubic yards of excavation. This cost should cover appurtenances, engineering, legal costs, etc. Chlorination equipment is estimated to cost $10,000 per facility.

F. When available, previous cost estimates formulated by the Montana State Department of Health and Environmental Sciences during the development of a U. S. Environmental Protection Agency needs list were used.

Ballantine-Worden

The sewage disposal system for the communities of Ballantine and Worden consists of gravity mains, two two-pump lift stations, and a two-cell lagoon. When the Ballantine system was constructed, the sewage collection system tied into the Worden system, and a new cell was added to the lagoon. The first cell has a surface area of 3.5 acres, and the second cell an area of 4.0 acres. The system serves an estimated population of 450 and seldom has a discharge to the Yellowstone River via a drain ditch. The lagoon system is loaded satisfactorily organically. They need the capability for series operation of at least three cells, and the capacity for holding winter flow. An additional 32,500 cubic yards of storage is expected to be needed to hold the winter flow. A chlorination unit is needed for disinfection. This will mean a cost of about $76,000 to ensure that the system has secondary treatment.

Custer

The sewage disposal system for the Community of Custer consists of gravity mains, a two-pump prefabricated lift station, and a two-cell lagoon. Both cells are equal in size, having a total surface area of 6.4 acres, and have been designed to be used in series. The system serves an estimated population of 600 and has never discharged. A discharge would be to the Yellowstone River via a drain ditch. There is no organic or hydraulic loading problem anticipated. Since the lagoon has no discharge, no additional facilities are needed.

Prairie Diner, Lounge, and Trailer Court

The sewage disposal system for the Prairie Diner, Lounge, and Trailer Court (about five miles east of Custer) consists of a gravity main and a small two-cell lagoon. The first cell has a surface area of about 1,250 square feet and the second cell an area of approximately 3,000 square feet. The system has been designed to be used in series. The system serves an estimated population of 40 and has never had a discharge. New construction on Interstate 94 will require that the lagoon system be moved. The Montana State Highway Department will construct a new lagoon facility during construction of this highway.

Hysham

The sewage disposal system for the Town of Hysham consists of gravity mains, a two-pump Can-Tex package sewage lift station, and a two-cell lagoon operated in series. Both cells are equal in size with a total surface area of approximately 5.0 acres. The system serves an estimated population of 300 and has an intermittent discharge to an irrigation return ditch and then to the Yellowstone River. The discharge is usually small, and when the irrigation ditch is not in use, the discharge seeps away before reaching the Yellowstone River. The lagoon system is loaded satisfactorily organically, but the capability for series operation of at least three cells is needed. An additional capacity of 1,700 cubic yards is needed for disinfection. This will mean a cost of $13,500 to ensure secondary treatment. Because of the beginning of coal mining in the Sarpy Creek area, the population of Hysham is expected to increase in the next several years. This will necessitate additions to the town's sewage system in addition to those mentioned above.

Forsyth

The sewage disposal system for the City of Forsyth consists of gravity mains, a small package lift station, and a two-cell lagoon. Both cells are equal in size and have a combined surface area of approximately 8.0 acres. At the present time the influent flow is split equally into both cells, but only one cell has a discharge. There is a pipe between the two cells which keeps the levels equalized. The system is capable of being operated in series. The effluent discharge is continuous and to a slough area well below the water level. The slough eventually drains to the Yellowstone River. The system serves a population of about 2,500 people. The waste discharge permit, which was issued to the city by the State of Montana on July 26, 1971, put them on a compliance plan. As part of this compliance, construction plans for sewage lagoon improvements were to be submitted to the State Department of Health and Environmental Sciences by July 1, 1972. The plans have not been submitted as yet but are in preparation by a consultant. The City of Forsyth is on the Montana State Department of Health and Environmental Sciences' priority list for EPA funding possibly for FY 1976. It is estimated that the system will need an additional 11.3 acres to obtain satisfactory organic loading. Also, 130,673 cubic yards of storage capacity will be needed to hold the winter flow. The capability of series operation of at least three cells is needed, and a chlorination unit will be needed for disinfection of the effluent. Cost of providing secondary treatment is estimated to be $144,000.

Rosebud

There are at least five small raw sewage discharges into the Yellowstone River from the Community of Rosebud. The original sewage disposal system for the community consisted of septic tanks and seepage pits. The seepage pits and drainfields eventually became clogged because of the soil type in this particular area. Small drain lines were constructed which tied the seepage pits and drainfields together and the sewage was then discharged to the Yellowstone River. The present population of about 150 is expected to increase in the next several years due to the increased coal development in the area. The community is not an incorporated town, and there are no county regulations for waste discharge or sewage facilities. The action the State of Montana has taken has been to set up a community meeting with county officials present to discuss the sewage disposal problem. The people have the choice of either constructing a community system under the Rural Sewer Improvement District (RSID) or adequately updating individual systems. Because of the condition of the seepage pits and drainfields due to the soil type and the possible increase in population, the Montana State Department of Health and Environmental Sciences recommended a non-discharging lagoon system.

Ashland

At the present time the sewage disposal system in the Community of Ashland is individual septic tanks. The Montana State Department of Health and Environmental Sciences has put the Community of Ashland on a needs list for a new community sewer system; however, it is expected that there will be at least a two or three year period before these funds are available. The community is adjacent to the Northern Cheyenne Indian Reservation, and there is an Indian housing development, Ashland Mutual Self Help Homes, at the St. Labre Indian Mission School on the Reservation in the nearby area. The Community of Ashland is not eligible to receive funds from the Public Health Service, administered by the Indian Health Service under PL 86-121, but the other two developments are eligible. When funding becomes available to provide the Community of Ashland with a sewage treatment facility, it may be possible in a dual-agency effort to facilitate the whole area.

Ashland Mutual Self Help Homes

The sewage disposal system for Self Help Homes on the Northern Cheyenne Indian Reservation near Ashland consists of gravity mains and a new two-cell lagoon. The total surface area of the two cells is approximately 1.8 acres. This system serves a population of about 80 people. At the present time the lagoon is still filling, and there is no sewage in the second cell. When the system is full, it will be operated in series, and the discharge will be to the Tongue River. The sewage disposal system appears to be of sufficient size to provide for the needs of this housing development. To ensure secondary treatment it is possible that another cell be constructed to provide three cells operated in series and a chlorination unit be installed to disinfect the effluent. Funds for this new system were provided by the Public Health Service. Since this system is on the reservation, its discharge permit will be issued under Federal discharge permit program.

St. Labre Indian Mission

The sewage disposal system for the St. Labre Indian Mission consists of gravity mains and a small two-cell lagoon. The total surface area of this lagoon is about 2.0 acres. Two or three years ago construction got underway to modify and upgrade the sewage disposal system. This included the construction of a larger lagoon cell and installation of a sewage lift station for the Mission School. At the present time the larger cell has been constructed, but not put into use; the lift station has not been completed; and a new package lift station has been received for an adjacent housing development that has been built in the last couple of years. When this facility is in full operation, the two lift stations will deliver sewage to the large cell, and from there it will be discharged to the Tongue River via a normally dry river channel. The original small lagoon will be used to treat storm water from the Mission area. It is doubtful that the system will meet secondary treatment requirements. The facility will probably have to be modified to provide for three cells operated in series, and a chlorination unit will have to be installed on the effluent. The St. Labre Mission School is on the Northern Cheyenne Indian Reservation, but because of its religious affiliation, it is not eligible for Federal Construction Grant funding from either the U. S. Environmental Protection Agency or the

U. S. Public Health Service. The waste discharge permit will be under the Federal discharge permit program.

Muddy Creek Home Sites

The sewage disposal system at the Muddy Creek Home Sites consists of gravity mains and a small two-cell lagoon. The total surface area of the lagoon system is about 0.8 acres. Seepage from the lagoon is such that all the liquid percolates into the ground. There is no pollution problem expected from this percolation, thus, the system is non-discharging. The system is servicing a population of about 50 people, with a total expected population of about 200 people. Muddy Creek Home Sites in on the Northern Cheyenne Indian Reservation and funding for this new facility was under PL 86-121, administered by the Indian Health Service. If at some future time, a waste discharge permit is needed, it will be issued under the NPDES permit program.

Lame Deer

The sewage disposal system for Lame Deer consists of gravity mains and a three-cell lagoon system. The surface area of the first two cells is about 4.8 acres and that of the third cell is about 5 acres. The first two cells are operated in parallel with the third cell being operated in series with the first two. This system serves an estimated population of 400 people. The lagoon effluent discharges to Lame Deer Creek via a small ditch. The lagoons seem to be loaded satisfactorily organically, and the system is capable of being run in series. The system is not adequate to store winter flows, and it is expected that about 9400 cubic yards of additional storage capacity will be needed. A chlorination unit will be needed on the effluent. It will cost an estimated $29,000 to provide secondary treatment. Lame Deer, being on the Northern Cheyenne Indian Reservation, will not be liable for a permit under the MPDES but will be issued a waste discharge permit through the Federal permit program.

Busby

The sewage disposal system for the Community of Busby consists of gravity mains and a two-cell lagoon. Both cells are about 1.5 acres in surface area. This system serves a population of about 200 and at present has no discharge due to excessive seepage. If at some future time the lagoon system should overflow, an additional cell may be needed for a three-cell series operation to provide the capacity for winter flow. Disinfection facilities may also be required. Since Busby is on the Northern Cheyenne Indian Reservation, its waste discharge permit comes under the NPDES permit program.

Colstrip

The sewage disposal system for the Community of Colstrip consists of gravity mains, two package lift stations, and a three-cell lagoon. These three cells have a total surface area of approximately 10.3 acres. The population served by this system is about 2000. At the present time there is no liquid in the third cell, and thus, the system is not discharging. It is expected that in the event sewage collects to the point where a discharge would occur that a new cell would be added.

Lodge Grass

The sewage treatment facilities for the Town of Lodge Grass consist of gravity mains and a single-cell lagoon with approximately six acres of surface area. A contract has been let by the Indian Health Service under funds provided by the U. S. Public Health Service to expand the lagoon system by adding a new cell. This system serves a population estimated at 700 people. The discharge is to the Little Bighorn River via a ditch. Lodge Grass is on the Crow Indian Reservation but has substantial non-Indian population. Therefore, funding from the U. S. Public Health Service under PL 86-121 does not cover the entire population of Lodge Grass. The town is on the Montana State Department of Health and Environmental Sciences' priority list for EPA funding for FY 1975, and it is planned that through a joint effort, the Lodge Grass sewage disposal system may provide secondary treatment. The present single-cell lagoon is slightly overloaded organically and needs an additional 2.0 acres of area. The capability for holding winter flow will necessitate approximately 42,600 cubic yards of additional capacity. A chlorination facility will be needed for disinfection of the effluent. Upgrading of this sewage disposal facility to ensure secondary treatment is expected to cost about $96,000.

Crow Agency

The sewage treatment facility for Crow Agency consists of gravity mains, two two-pump lift stations, and a three-cell lagoon. The total surface area of the three-cell lagoon is approximately ten acres. The system is operated with the first two cells in parallel and the third cell in series. The discharge is to the Little Bighorn River via a drain ditch. The system serves a population of 1,000 people and the Bighorn carpet mill. This system was found to be inadequate for treating the industrial wastes from the carpet mill. Construction is presently underway and scheduled for completion in October 1974 of a physical-chemical treatment facility. This new mechanical treatment plant will receive the industrial waste prior to its discharge into the lagoon system, and it will also receive a portion of the municipal waste from the community. The rest of the municipal waste will discharge directly into the lagoon system. The lagoon system does not appear to have the capacity for holding winter flow, and an additional 45,000 cubic yards of storage may be needed. A chlorination unit may be needed to ensure disinfection of the effluent. These additions to the sewage disposal system will cost approximately $101,000.

Hardin

The sewage disposal system for the City of Hardin consists of gravity mains, a two-pump master lift station, a small two-pump lift station, and a two-cell lagoon with a total surface area of about 25 acres. This system serves an estimated population of 2700 people. Each cell has its own discharge; one discharges to a ditch and then to the Bighorn River; the other discharges directly to the Bighorn River. The City of Hardin is on the Montana State Department of Health and Environmental Sciences' priority list for EPA funding for FY 1975. The lagoons are slightly overloaded organically and an additional 2.5 acres is needed. There is the need for capability of series operation of at least three cells. The capacity for holding winter flow appears to necessitate another 121,933 cubic yards of storage. Disinfection of the effluent may require a chlorination unit. A new collector for an interceptor sewer is also needed. A total cost of $223,200 will be needed to make these necessary improvements. There is quite a population increase expected due to the increased coal development in the area. This may require additional improvements to ensure secondary treatment.

St. Xavier

The sewage treatment facility for the Community of St. Xavier and the St. Xavier Mission School consists of gravity mains, a two-pump lift station, and a two-cell lagoon with approximately one acre of surface area. This system serves an estimated population of 75 people. The discharge from this system is directly to Rotten Grass Creek. The lagoons are in very poor condition at this time. The second cell is not being utilized, and the first cell is full and is discharging continuously to Rotten Grass Creek. The surface area and capacity of the lagoon system is such that with proper maintenance no discharge should occur. The Community of St. Xavier and the Mission School are on the Crow Indian Reservation. The community is mostly non-Indian, and because of the Mission School's religious affiliation, no funding is possible through the U. S. Public Health Service. Funding is possible through the U. S. Environmental Protection Agency for the community but not the Mission School. An estimated $2,500 will be needed to restore the lagoon system to proper maintenance.

Park Dale Court at Fort Smith

The sewage disposal system for this trailer court consists of gravity mains and a single-cell non-discharging lagoon with approximately one acre of surface area. The lagoon was designed to handle the population during the height of construction of Yellowtail Dam. The decline in population has resulted in the lagoon being oversized for the present population and, thus, a non-discharging facility.

Yellowtail Dam Housing Complex

The sewage disposal system for this complex consists of gravity mains discharging into a two-cell lagoon with a total surface area of three acres. The system discharges directly to the Bighorn River afterbay. The population estimated to be served by this system is 175 people. The system is satisfactorily organically and hydraulicly loaded. The system may have to be modified to provide series operation of at least three cells and a chlorination unit to provide disinfection of the effluent. This will cost an estimated $10,000 to ensure secondary treatment. This is a federal installation operated by the U. S. Bureau of Reclamation and the waste discharge permit is under the jurisdiction of the NPDES discharge permit program.

Yellowtail Visitors Center

The sewage disposal system for the Visitors Center is an extended aeration plant. This unit consists of a bar screen, aeration chamber, final clarifier with sludge return, and overflow wier. The discharge from this system is to Yellowtail Reservoir. The center is only open during the summer months, and therefore, the system is not in continuous use. The system should provide adequate secondary treatment with the exception of disinfection. Disinfection will require the addition of a chlorination unit. This will cost an estimated $10,000. This is a federal installation run by the U. S. Park Service, and the waste discharge permit is under the jurisdiction of the NPDES permit program.

Yellowtail Dam Power Plant

The sewage disposal system for the power plant is a small extended aeration plant. This plant consists of a bar screen, an aeration chamber, final clarifier with sludge return, and overflow weir. The discharge from this system is to the Bighorn River afterbay. The system has a continuous discharge due to the continuous trickling of a water fountain. This, also, provides dilution water for the sewage. This system serves a population of approximately 50 employees and should provide adequate secondary treatment with the exception of disinfection. A chlorination unit on the effluent would ensure disinfection. This addition to the system will cost an estimated $10,000. The Yellowtail Dam Power Plant is run by the U. S. Bureau of Reclamation and is, thus, a federal installation. The waste discharge permit for this system comes under the jurisdiction of the NPDES program.

Pryor

At the present time the sewage disposal system for the Town of Pryor consists of individual septic tanks. The community is on the Crow Indian Reservation, and funds have been made available for construction of a community sewage disposal system of gravity mains and a lagoon. At this time the community is in the process of selecting a lagoon site. These funds are from the U. S. Public Health Service, administered by the Indian Health Service. There is a substantial non-Indian population in the community, and it is hoped that through a joint effort by the Indian Health Service and the Montana State Department of Health and Environmental Sciences that the community can be provided with secondary treatment. Since the community is on an Indian reservation, the waste discharge permit will come through the NPDES Program.

The "Montana Water Pollution Control Program Plan" prepared for EPA by the WQB, June 15, 1974, includes a priority ranking for EPA sewage treatment construction grants. Lodge Grass, Hardin, Forsyth, Ashland, and Huntley are the only municipalities in the Middle Yellowstone Basin on this list. Ashland and Huntley do not presently have community sewage systems and their priority is based on this need. With the exception of Pryor all the other communities in the Middle Yellowstone Basin with individual sewage systems are not at present presenting a pollution problem. A priority rating has been developed for the municipal dischargers in the basin based on the same priority system outlined in "Water Pollution Control Program Plan," WQB,

TABLE 5

BASIN WASTE SOURCE INVENTORY
MUNICIPAL DISCHARGE

STATE Montana
BASIN Middle Yellowstone
SEGMENT
TYPE WASTE SOURCES Municipal

WASTE SOURCE IDENTIFICATION DATA					WASTE SOURCE QUANTITY AND QUALITY DATA													
		DISCHARGE LOCATION					PARAMETERS OF IMPORTANCE[5]								ADDITIONAL PARAMETERS			
							BOD5			TSS			pH	Fecal Coliform	Nutrients		Est. (P.E.)	
NAME OF WASTE SOURCE	TYPE OF TREATMENT	RECEIVING WATER	TNS RNG SEC TRACT[1]	DISCHARGE PERMIT NO.[2]	AVERAGE DAILY FLOW[3]	TYPE OF DISCHARGE	mg/l	#/day	%Remvl	mg/l	#/day	%Remvl	S.U.	number/100 ml.	mg/l NO3	mg/l PO4	Trtd	UnTrtd
Ballantine-Worden	2-cell lagoon	Yellowstone River	03N 29E 30 ADB	765-1 (S)	0.01	I											0	600
Custer	2-cell lagoon	None	04N 33E 91 AAA	None	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	200
Hysham	2-cell lagoon	Yellowstone River	06N 36E 05 BCD	MT-0021-709 (E)	0.04	I	32.6	10.0	88.7	105	32.3	30.0	7.60	2.0x10^5	0.79	16	0	300
Prairie Diner, Lounge & Trailer Court	2-cell lagoon	None	05N 34E 31 DDA	None	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	400
Forsyth	2-cell lagoon	Yellowstone River	06N 40E 13 CAA	MT-0021288 (E)	0.05	C	103.	39.6	60.1	20.0	7.7	94.1	7.40	2.5x10^4	1.3	24	100	1850
Rosebud	Raw disc.	Yellowstone River	06N 42E 14 BC	None		C	---	---	---	---	---	---	---	---	---	---	---	---
Ashland Mutual Self Help	2-cell lagoon	Tongue River	03S 44E 03 DDD	None	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
St. Labre Mission School	2-cell lagoon	Tongue River	03S 44E 03 ADA	?	0.01	I	---	---	---	---	---	---	---	---	---	---	0	250
Lame Deer	3-cell lagoon	Lame Deer Creek	02S 41E 33 AAD	1275-1 (S)	0.65	C	40.0	200.	89.0	40	200.	84.1	8.00	1.3x10^5	1.7	15.	0	400
Muddy Creek Homesites	2-cell lagoon	None	02S 40E 35 CBA	None	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	50
Busby	2-cell lagoon	None	03S 39E 31 ABD	None	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	300
Colstrip	3-cell lagoon	None	02N 41E 34 BBA	None	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	700
Lodge Grass	1-cell lagoon	Little Bighorn River	06S 35E 12 DDC	MT-0021890 (E)	0.10	C	60	46.1	79.0	---	---	---	7.60	1.9x10^4	0.55	9.74	200	600

[1] See explanation of description in Appendix
[2] S - State issued; E - EPA issued; 'C - Corps of Eng. issued'
[3] For period of discharge, values in MGD
[illegible]

TABLE 5

BASIN WASTE SOURCE INVENTORY

MUNICIPAL DISCHARGE

STATE
BASIN
SEGMENT
TYPE WASTE SOURCES

WASTE SOURCE IDENTIFICATION DATA					WASTE SOURCE QUANTITY AND QUALITY DATA													
NAME OF WASTE SOURCE	TYPE OF TREATMENT	DISCHARGE LOCATION		DISCHARGE PERMIT NO.[2]	AVERAGE DAILY FLOW[3]	TYPE OF DISCHARGE[4]	PARAMETERS OF IMPORTANCE[5]								ADDITIONAL PARAMETERS			
		RECEIVING WATER	TNS RNG SEC TRACT[1]				BOD_5			TSS			pH	Fecal Coliform	Nutrients		Est.	(P.E.)
							mg/l	#/day	%Remvl	mg/l	#/day	%Remvl	S.U.	number/100 ml.	mg/l	mg/l	Trtd	UnTrtd
Crow Agency	3-cell lagoon	Little Bighorn River	03S 34E 01 AAA	MT-002-0800 (E)	0.08	C	73.0	40	81	21.7	10	---	7.50	10^4	NO_3 0.65	PO_4 47.7	0	2000
Hardin	2-cell lagoon	Bighorn R.	01S 33E 24 DDB	MT-0020-834 (E)	0.10	C	83.0		55	47.5		---	7.55	$1.8x10^5$	1.11	18.3	600	3000
St. Xavier	2-cell lagoon	Bighorn R.	04S 32E 23 DCC	None	0.005	C	300	10	63	23.2	0.9	---	7.80	$2.0x10^4$	1.59	37.0	0	75
Park Dale Court	Single cell lagoon	None	06S 31E 18 ADD	None	None	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Yellowtail Dam Housing Complex	2-cell lagoon	Bighorn R.	06S 31E 18 ACD	MT-0022993 (E)	0.01	I	---	---	---	---	---	---	---	---	---	---	---	---
Yellowtail Visitors Center	Extended aeration plant	Yellowtail Reservoir	06S 31E 18 DCA	None	0.003	I	---	---	---	---	---	---	---	---	---	---	---	---
Yellowtail Dam Power Plant	Small extended aeration plant	Bighorn R.	06S 31E 18 DCB	MT-0022993 (E)	0.003	C	---	---	---	---	---	---	---	---	---	---	---	---

[1] See explanation of description in Appendix
[2] S - State issued; E - EPA issued; C - Corps of Eng. issued
[3] For period of discharge, values in MGD
[4] C - Continuous; I - Intermittent (Discharge Period Shown)
[5] Those parameters listed on the discharge permit

June 15, 1974. Below is a ranking of the municipal dischargers in the Middle Yellowstone Basin listed by priority:

- Lodge Grass
- Hardin
- Forsyth
- Crow Agency
- Lame Deer
- Hysham
- Rosebud
- St. Xavier
- St. Labre
- Yellowtail Dam Housing Complex
- Ballantine/Worden
- Yellowtail Visitors Center
- Yellowtail Dam Power Plant
- Colstrip
- Ashland Mutual Self Help Homes
- Muddy Creek Home Sites
- Busby
- Park Dale Court
- Prairie Diner, Lounge, and Trailer Court

WATER TREATMENT PLANT DISCHARGES

Forsyth

There are no discharge treatment facilities for the water treatment plant at Forsyth. The water treatment consists of a presedimentation basin for primary settling. The mud from this basin is cleaned once or twice a year by flushing into the Yellowstone River. The filter backwash is discharged into the Yellowstone River.

Hardin

There is no discharge treatment facility for the water treatment plant discharge at Hardin. The filter backwash is discharged into the city storm sewer which in turn discharges into the Bighorn River.

St. Labre

The discharge treatment facilities for the water treatment plant at St. Labre consist of a series of three settling ponds. Sludge from the solids contact unit and filter backwash is to the Tongue River. These settling basins are dredged periodically and the dredgings piled along the banks of the Tongue River.

Crow Agency

There is no discharge treatment facility for the water treatment plant discharge at Crow Agency. Sludge from treatment unit and filter backwash are discharged directly into the Little Bighorn River.

Miles City

There is no discharge treatment facility for the water treatment plant in Miles City. Settled sludge from presediment basins and the flocculation chambers is discharged directly to the Yellowstone River. Filter backwash is also discharged into the river. A new plant is now under construction which will have settling basins for these discharges.

INDUSTRIAL DISCHARGES

This section includes those industrial waste discharges that are under state permit or are liable to be under the NPDES or MPDES permit programs.

Soap Creek Association, Inc. - Soap Creek Oil Field

The water treatment and discharge facilities at the Soap Creek Oil Field consist of three skimming ponds in series with the final discharge to Soap Creek. A second skimming pond system is used, but the discharge from this system is to a swampy area where it either evaporates or infiltrates into the ground. When oil collects on these ponds, it has been the practice to burn them off, so no oil runs into Soap Creek. The system provides for settling, but no other treatment is done on the discharge. This oil field is on the Crow Indian Reservation, and therefore, the waste discharge permit is under the jurisdiction of the NPDES permit program. No permit has as yet been issued.

Westmoreland Resources Coal Mining Operation

The water treatment and discharge facilities for the coal mining operation consistsof ditches forming a storm drainage system for the mining area and a settling pond. Any water derived from the mining pits is pumped into the storm drainage system. The system provides for settling but no other treatment is done on the discharge. The discharge is to Sarpy Creek and is intermittent in nature. A waste discharge permit has been issued under the NPDES permit program (MT-0021229).

Peabody Coal Company

The water treatment and discharge facilities for the coal mining operation consist of a series of settling pits. The discharge from this pit goes to a rancher's stock watering pond. Peabody has made a commitment to the rancher to maintain an adequate water level in the stock pond. There has been no discharge from this stock pond. If in the future a discharge does occur from the stock pond, a discharge permit will be required as the discharge will enter Rosebud Creek via Miller Coulee. The discharge permit would come under the MPDES permit program.

Decker Coal Company

The water treatment facilities for the coal mining operation consist of a settling pond. Discharge from this pond enters a marshy area which in turn drains to the Tongue River. The system provides for settling as the only treatment before discharge, which is intermittent in nature. Decker Coal Company is under the NPDES permit program and will be shifted to the MPDES permit program (MT-0000892).

Forsyth Ready Mix

Water treatment facilities for the gravel washing operation consist of a settling pond with a discharge channel. This pond is actually a diked up channel of the Yellowstone River which floods during high flow. There is a cut in the retaining dike which discharges directly into the Yellowstone River. The company is in the process of building a new plant which will contain a classifier that will remove almost all the silt from the wash water. The water will then enter the diked up river channel. The cut in the retaining dike will be filled in. Since the river channel floods during high flow, a discharge permit will be needed and will come under the MPDES permit program. No discharge permit has, as yet, been issued.

Table 6
Industrial waste quality and quantity data.

Industry and Location	Average Daily Flow MGD	pH	k_{25}*	Total Dissolved Solids (TDS)		Total Suspended Solids (TSS)		Total Iron (Fe)		Total Sodium (Na)	
				mg/L	T/day	mg/L	T/day	mg/L	T/day	mg/L	T/day
Decker Coal Company 09S 40E 15CB	0.13	8.5	1840	1566	0.88	12	0.001	1.2	<.001	372	0.21
Westmoreland Resources 01N 37E 26AD	0.012	7.6		611	0.03	16	0.001	0.21	<.001	41	0.002

*k_{25} = specific conductance in micromhos/cm at 25° C.

AGRICULTURAL WASTE DISCHARGES

Extensive information regarding agricultural waste discharges is not readily available but a variety of such discharges are known to be present within the basin. Such discharges include irrigation return flows, animal confinement facilities, and runoff from range and cultivated land. The information contained in this report has been compiled from data collected in conjunction with the Montana Pollutant Discharge Elimination System and from limited field observations. The following animal confinement facilities have received MPDES permits.

Treasure State Cattle Feeders - Permit No. MT-0023329, issued July 24, 1974

Treasure State Cattle Feeders, Inc. proposes to construct a confined livestock feeding operation having a capacity for 5,000 feeder cattle. The proposed feeding operation encompasses approximately 50 acres and would be located in the SW¼ of the NE¼ of Sec. 17, T. 1 S., R. 34 E., of Big Horn County, approximately two miles northeast of Hardin, Montana. All surface runoff and manure from the feeding area will be contained in one or more retention ponds which will be constructed on the natural drainage at the lower end of the feeding area. The waste material which accumulates in the retention ponds will then be removed by a floating pump and disposed of on surrounding agricultural land. The solid material which accumulates in the bottom of the retention pond will be periodically removed and again spread on adjacent agricultural land. Waste material will be hauled to adjacent agricultural land.

T-Bone Feeders, Inc. - Lot No. 2 - Permit No. MT-0023311 issued Aug. 30, 1974

T-Bone Feeders, Inc. currently operates a confined livestock feeding operation having a capacity for approximately 30,000 head of cattle at their Lot No. 2 location. This feeding operation encompasses approximately 140 acres and is located northeast of Shepherd, Montana in the SW¼ of Sec. 19 and the NW¼ of Sec. 30, T. 30 N., R. 28 E., of Yellowstone County. Extraneous drainage from the area above the feeding operation is prevented from reaching the feedlot area by a water storage reservoir. Surface runoff generated within the confined feeding operation is routed through open channels to a large retention pond located southeast of the feeding area. This retention pond has a storage capacity in excess of 700 acre inches. The runoff which accumulates in this retention pond is then disposed of as necessary on adjacent agricultural land. Waste material is then removed from the feeding area itself twice per year and again spread on agricultural land in the area.

Floyd Warren, Inc. Feedlot - Permit No. MT-0022543, issued Oct. 30, 1974

Mr. Darroll Warren currently operates a commercial cattle feeding operation having a total capacity for approximately 2,500 cattle. The operation is located in the W½, NW¼, Sec. 4, E½, NE¼, and the NE¼ of the SE¼ of Sec. 5, T. 1 S., R. 34 E., of Big Horn County approximately five miles southeast of Hardin, Montana. Extraneous drainage is prevented from reaching the feeding area by a diversion structure constructed along the western edge of the feeding area. The contaminated surface runoff will be contained by retention structures which have been constructed along the lower portion of the feeding area. The runoff which accumulates in the retention structures will be disposed of by evaporation or by pumping onto adjacent agricultural land. Waste material which accumulates on the feedlot surface is likewise removed and disposed of on surrounding agricultural land.

Razor Creek Farms - Permit No. MT-0029024, issued October 22, 1974

Mr. Elmer Quanbeck currently operates an animal confinement facility having a capacity for approximately 600 head of cattle. This feeding operation encompasses approximately 3 acres and is located northeast of Shepherd, Montana in the NE¼, SW¼, Sec. 36, T. 3 N., R. 27 E., of Yellowstone County. Extraneous drainage is prevented from reaching the feeding area due to the flat topography of the feeding area and access road. Minimal runoff should result from the area and any runoff which would occur could be routed to adjacent agricultural land. This runoff should be contained on the applicant's property with little possibility of ever reaching state waters. Waste material is removed from the feeding area twice per year and spread on agricultural land owned by the operator.

Allen Propp and Sons Feedlot - Permit No. F-18-B, issued August 14, 1973

Mr. Allen Propp operates an animal confinement facility having a capacity for approximately 1,000 head of cattle. This operation is located 1-1/2 miles east of Worden, Montana in the NW¼, NE¼, Sec. 32, T. 3 N., R. 29 E., of Yellowstone County. Surface runoff is contained naturally on the owner's property and should not contribute to water pollution. Waste material is removed periodically to reduce odors.

Nayematsu Bros. Inc. Feedlot - Permit No. MT-0029028, issued Nov. 29, 1974

Mr. Yugo Nayematsu currently operates an animal confinement facility north of Hardin, Montana having a capacity for approximately 950 head of cattle. This feeding operation encompasses approximately 3.5 acres and is located in the SW¼, SW¼, Sec. 4, T. 1 N., R. 33 E., of Big Horn County. Extraneous drainage is prevented from reaching the feeding area due to the topography of the area and the access road on the west. Minimal runoff should result from the area and any runoff which would occur is routed onto adjacent cropland. This runoff should be contained on the applicant's property with little possibility of ever reaching state waters. Waste material is removed from the feeding area once per year and spread on adjacent agricultural land.

The following animal confinement facilities within the basin are suspected of having water pollution potential:

Owner or Operator	Approximate Size	Approximate Location
T-Bone Feeders, Lot #1	15,000 beef	02N 27E 10AD
Scott Feedlot	30,000 beef	01S 29E 22-29, 34 02S 29E 3-9, 15, 16, 21

Owner or Operator	Approximate Size	Approximate Location
Enzminger Brothers	1,000 beef	2 mi. south of Hardin
Clyde Hawks, Inc.	1,500 beef	near St. Xavier
Daniel Vogel	3,000 beef	02N 28E 13BB
Rector Cattle Co.	4,500 beef	02N 27E 15CB

Irrigation return flows are subject to MPDES permit requirements if there is a point source discharge through a man-made or man-maintained drainage system from 3,000 or more irrigated acres. The following applications have been received in accordance with the MPDES Rule.

Applicant Name	Location	Number of Irrigated Acres	Estimated Return Flow in Acre-Feet Per Year
Huntley Project Irrigation District	Ballantine	27,000	35,000
Hysham Water Users' Association	Hysham		
Big Horn Low Line Ditch Company	Hardin	6,000	15,000
Two Leggins Water Users' Association	Hardin	21,700	

The parameters to be monitored in conjunction with the permits and the frequency of monitoring will be stated on the waste discharge permit.

NON-POINT SOURCES

Little consideration has been given to non-point sources in the past because of the difficulty in their identification. Pollutants contributed by these sources within the basin may be significant. Although any one specific area of non-point waste may have a minor effect, several such sources on a stream may produce water quality problems. Non-point pollution arises from a variety of activities, including agriculture, runoff from urban areas, construction projects, inadvertent spills, and natural phenomena.

Irrigation return flows from numerous small areas can exhibit this cumulative effect on state waters. These flows are higher in total dissolved solids and sediment and contain more nutrients and pesticides than water applied to the field.

Runoff from pasture lands may carry animal wastes and sedimentation to state waters. A number of pastures in the basin use streams as a boundary. In many cases in these pastures there is no vegetation on the stream bank or in the immediate floodplain due to livestock concentrating in these areas. As a result, there is no protection from erosion due to irrigation, storm runoff, and high water. The use of lands in the basin that exhibit sparse vegetation due to fragile soils for pastures tends to amplify stream sediment in these areas.

Runoff from agricultural land where saline seep has been allowed to develop presents another potential non-point source pollution problem. Although only a few areas within the Middle Yellowstone Basin have been defined strictly as saline seep areas, it is expected that the ongoing studies will identify additional seep areas.

Runoff from cultivated lands may present potential non-point pollution problems from fertilizers, pesticides, dissolved salts, and sediment. Increased demand for food causes an increased demand for farm products and this in turn leads to the use of more fertilizers and pesticides to increase the yield on agricultural lands. Removal of brush and trees from stream banks and the floodplain to increase stream access, control weeds, and increase the amount of cropland causes increased erosion.

Community storm drain systems present another non-point pollution source due to a variety of hazardous materials including: oil and grease, coliforms, biologically oxidizable material, suspended solids, plus various toxic metals. The EPA has to date excluded storm drainage from the NPDES program and they have been excluded from the MPDES permit program. The impact of these discharges on water quality in the Middle Yellowstone Basin is probably significant.

Construction projects and stream bank riprapping are important non-point pollution problems. Increases in coal and energy related development in the basin will increase this type pollution. Increases in population project to occur in the basin will increase the number of inadvertent spills of toxic or deleterious materials into surface or groundwater systems.

In view of the lack of existing information on non-point sources, any rating of relative priorities of these sources can only be developed as to their suspected impact on receiving waters and to their future potential. With this constraint the following is the non-point priority list for the basin:

(1) agricultural non-point discharges,

(2) storm drains and urban runoff,

(3) construction projects (subdivisions, roads, bridges, riprapping etc.),

(4) accidental discharges (spills), and

VI. WASTE LOAD ALLOCATION

All surface waters in the Middle Yellowstone Basin are effluent limited segments and therefore no waste load allocations have been made. As the limited data collected during this basin study indicates, fecal coliform concentrations violate state water quality standards for several streams at various times. The state standards for $B\text{-}D_1$, $B\text{-}D_2$, and $B\text{-}D_3$ surface water classifications, which all surface waters in the Middle Yellowstone are classified, allow for only 10% of the total number of samples collected during any 30-day period to exceed 400 fecal coliforms (F.C.) per 100 milliliters (ml). Below is a short list showing streams, dates, and concentrations which are greater than 400 F.C./100 ml.

LOCATION	DATE	F.C./100 ml
Pryor Creek at Huntley	6/6/74	1100
Hay Creek near Pryor	5/15/74	>1000
East Fork Creek near Hardin	5/30/74	>1000
Yellowstone River at Huntley	8/8/72	2000
Pass Creek near Wyola	5/1/74	580
East Owl Creek near Lodge Grass	5/15/74	600
Soap Creek near St. Xavier	5/1/74	610
Rotten Grass Creek nr St. Xavier	12/20/73	2000
Rotten Grass Creek nr St. Xavier	5/1/74	900
Rosebud Creek nr Kirby	2/28/74	3000
Rosebud Creek at Busby	1/17/74	500
Lame Deer Creek nr Lame Deer	1/30/74	550
Pumpkin Creek nr Miles City	5/20/74	5000
Sarpy Creek blw Westmoreland	1/18/74	500
Armells Creek nr Forsyth	1/22/74	1100
Sweeny Creek nr Rosebud	1/21/74	460

These conditions are apparently created by non-point discharges that were not clearly identified in this study.

VII. SURFACE WATER RESOURCES

The Middle Yellowstone River Basin contains nine sub-basins. The major streams in these sub-basins are (1) the Yellowstone River mainstem from the confluence of Pryor Creek to the confluence of the Bighorn River, (2) Sage Creek, (3) Pryor Creek, (4) Bighorn River, (5) Little Bighorn River, (6) Yellowstone River mainstem from the confluence of the Bighorn River to the confluence of the Tongue River, (7) Rosebud Creek, (8) Tongue River mainstem from the Montana/ Wyoming state boundary to the confluence of Hanging Woman Creek, (9) Tongue River mainstem from the confluence of Hanging Woman Creek to the confluence with the Yellowstone River. The U. S. Geological Survey has maintained numerous stream flow gaging stations in or adjacent to the basin. At the present time 26 of these stations are active. For many of the streams in the Middle Yellowstone Basin, there are considerable variations in the daily, monthly, and annual discharge. Examining the stream flow data for the Yellowstone River at Billings and at Miles City shows that the spring runoff originating within the basin prairie region occurs between March and early May. A minor peak in discharge in the Yellowstone is evident during this period. A major portion of the annual flow occurs at this time for various tributary streams of the Yellowstone, Bighorn, and Tongue Rivers. For these rivers, the annual maximum flow and the major portion of annual discharge occurs anywhere from mid-June to mid-July. This is due to the runoff from the mountain snow pack in the rivers' upper drainage. The Bighorn and Tongue Rivers are regulated by reservoirs. The remaining streams in the basin, however, may have their high or even peak yearly flows in mid-winter due to chinook warming trends or in spring and summer due to heavy rain storms, which is characteristic of a semi-arid prairie area. Late winter to early spring is the period these creeks have their principal flow. Sparse vegetation in a majority of the basin and soils of low infiltration rates produce conditions favorable for rapid runoff and rapid changes in flow. Some of the figures in this section are schematic diagrams of the major streams in each of the sub-basins in the Middle Yellowstone River Basin. Table 7 summarizes stream flow data for various streams in the Middle Yellowstone River Basin.

SAGE CREEK SUB-BASIN

Sage Creek is the only perennial stream in this 210 square mile sub-basin (Plate I and Fig. 1). The headwaters of Sage Creek arise on the northern slopes of the Pryor Mountains and the creek is fed by many springs in this area. Sage

Table 7

Summary of Sub-basin Size and Stream Flow From Gaged Streams in the Middle Yellowstone River Basin

STATION	LOCATION	DRAINAGE AREA (Sq. Miles)	YEARS OF RECORD	MIN. STRM. FLOW (cfs)	AVERAGE ANNUAL FLOW (cfs)
Pryor Creek at Pryor	05S 26E 05ABA	117	4/21 - Present 6 Contin.	3.4	32.6
Pryor Creek above Pryor	06S 26E 06CA	39.6	4/21 - Present 6 Contin.	0	7.62
Yellowstone River at Billings	01N 26E 34AA	0 On W Edge of Basin	8/28 - Present	430	6,858
Fly Creek at Pompeys Pillar	09N 30E 23BD	285	10/69 - 9/72	1.7	58.3
Bighorn River near St. Xavier	06S 31E 16BA	3,500 In MT	1934-Present	49 Dam closure	3,550
Soap Creek near St. Xavier	06S 32E 10A	98.3	3/39 - 9/72 (Interm.)	1.0	30.6
Rotten Grass Creek near St. Xavier	05S 33E 07A	147	10/19 - 9/72 (Interm.)	0	31.2
Beauvais Creek near St. Xavier	04S 30E 15BC	100	7/67 - Present	0.5	18.7
Little Bighorn River at state line	09S 33E 36CB	0 In MT	3/39 - Present	21	150
Little Bighorn River near Wyola	07S 35E 35ACC	253	3/39-Present (Interm.)	12	205
Lodge Grass Creek near Wyola	08S 34E 19BB	80.7	3/39 - Present	3.0	49.1

Table 7
(continued)

STATION	LOCATION	DRAINAGE AREA (Sq. Miles)	YEARS OF RECORD	MIN. STRM. FLOW (cfs)	AVERAGE ANNUAL FLOW (cfs)
Pass Creek near Wyola	09S 35E 13A	20 In MT	6/35 - 9/56 (Interm.)	0	36.1
Little Bighorn River near Hardin	01S 34E 19AA	1,101	6/53 - Present	0.2	285
Bighorn River at Bighorn	05N 34E 33AA	6,000 in MT	5/45-Present	400	3,851
Tongue River at state line	09S 40E 33BA	0 in MT	10/61-Present	3.9	493
Tongue River at Dam	08S 40E 13A	293	5/39 - Present	0 Dam closure	449
Tongue River near Ashland	01S 44E 10BD	2,353	10/67 - Present	50	610
Tongue River at Miles City	07N 47E 23D	3,902	4/38 - Present (Interm.)	0	423
Yellowstone River at Miles City	08N 47E 28BC	10,600 Approx.	9/22 - Present (Interm.)	996	11,330
Rosebud Creek near Forsyth	05N 42E 09C	1,270	10/48 - 9/53	0	24.0
Sage Creek near Lovell		210 in MT	5/51 - 9/60	10	106

Creek arise on the northern slopes of the Pryor Mountains and the creek is fed by many springs in this area. Sage Creek travels east-northeast along the base of the Pryor Mountains and then turns south flowing into Wyoming and finally emptying into the Shoshone River near Lovell, Wyoming. There are several reservoirs on the creek. Those in the upper drainage are small and used for stock watering, where as those in the lower drainage are somewhat larger and provide water for flood irrigation as well as stock watering. There are no active U. S. Geological Survey flow gaging stations in this sub-basin. The Survey maintained a gaging station at Lovell, Wyoming, and near Deaver, Wyoming. Figure 5 shows monthly mean discharge and an average monthly mean discharge in cubic feet per second (cfs) for Sage Creek near Lovell, Wyoming. This data is quite biased due to irrigation return waters from land irrigated by canals diverting water from the Shoshone River (Ref. 26). Since the Shoshone River in this area has such a high sediment concentration, headgates are kept open, so they will not become silted shut. Thus, except at relatively low flows water is being diverted from the Shoshone River into Sage Creek. For the period of record the maximum discharge was 1290 cfs and the minimum was 10 cfs. There is some flow data on Sage Creek near Deaver, Wyoming, about 10 miles upstream from Lovell, Wyoming. This station is also affected by irrigation return flow from waters diverted from the Shoshone River (Ref. 26). Flows were measured when samples were collected on Sage Creek by the Water Quality Bureau of the Montana State Department of Health and Environmental Sciences in preparation of this study. The upper sampling site was at Bridger Camp at the base of the Pryor Mountains. The other sampling site was at the Montana/Wyoming state boundary near Warren, Montana. These flows are considerably less than those shown in Figure 5 (see the Water Quality section).

PRYOR CREEK SUB-BASIN

There are five perennial streams in this sub-basin; East Fork Creek, Hay Creek, East Fork of Pryor Creek, West Fork of Pryor Creek, and mainstem Pryor Creek. All the other streams are for the most part intermittent with most of them being tributary to Pryor Creek in its lower reach, below Pryor, Montana (Plate I, Fig. 1). The sub-basin is approximately 610 square miles in size. With exception of East Fork Creek all other streams originate at the base of the northern slopes of the Pryor Mountains. East Fork Creek originates in the badlands on the eastern side of this sub-basin. Pryor Creek has the largest drainage area, the others being tributaries. Pryor Creek flows northward

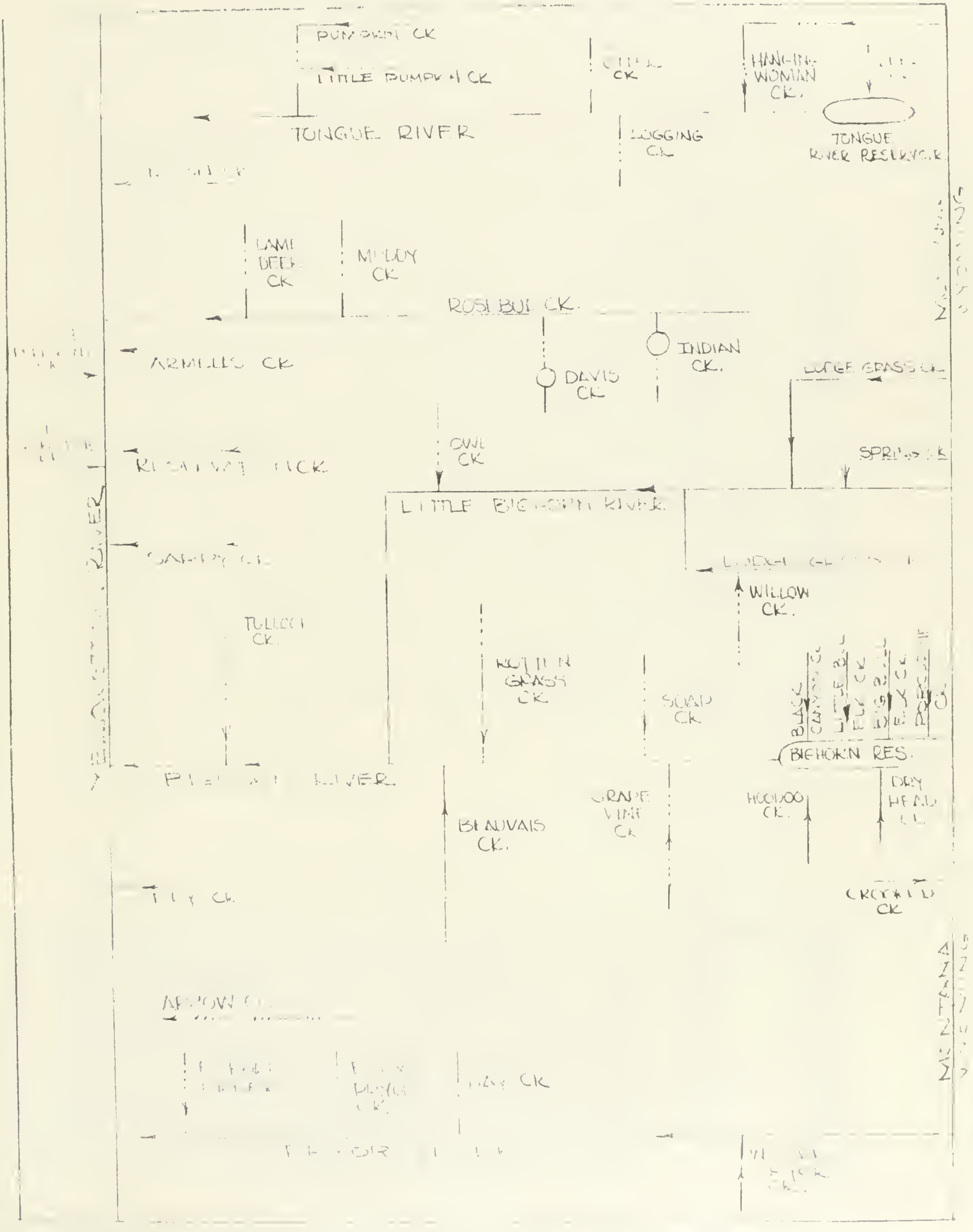


FIGURE 4. SCHEMATIC DIAGRAM OF WATERS IN THE MIDDLE YELLOWSTONE RIVER BASIN

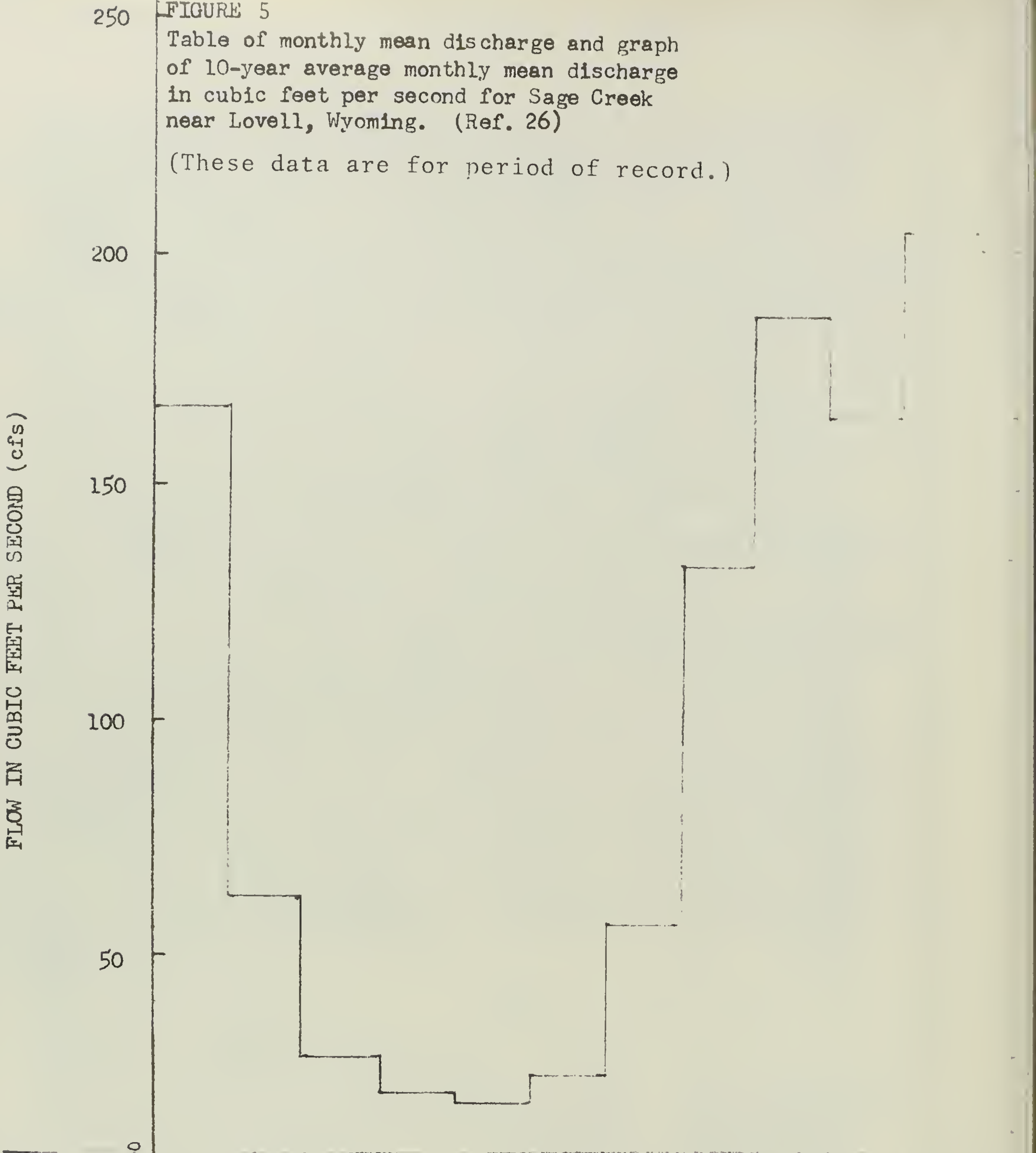


FIGURE 5

Table of monthly mean discharge and graph of 10-year average monthly mean discharge in cubic feet per second for Sage Creek near Lovell, Wyoming. (Ref. 26)

(These data are for period of record.)

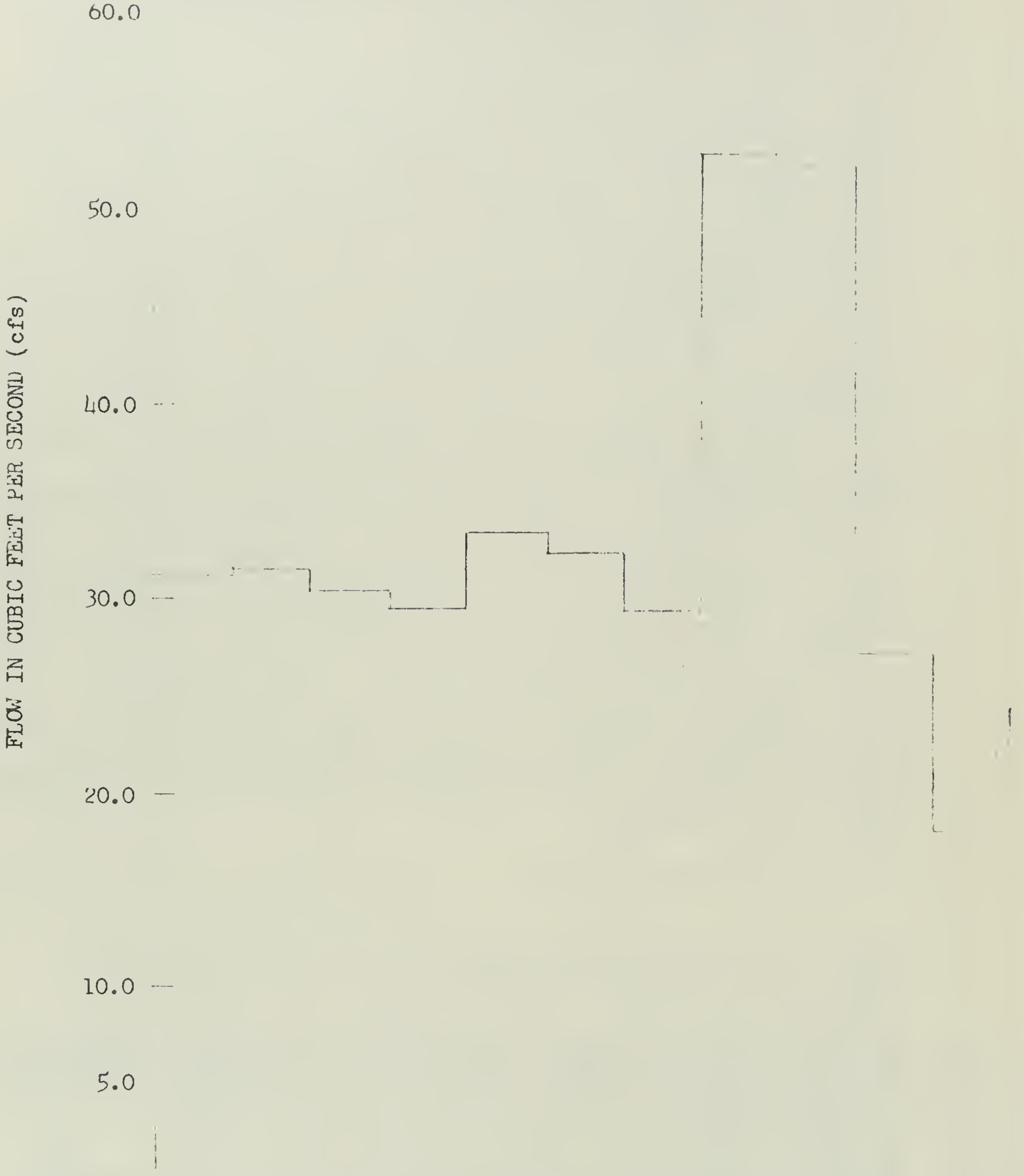
Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1951	-----	-----	-----	-----	-----	-----	- - -	110	149	183	187	196
1952	113	51.0	23.4	13.6	14.2	20.2	52.2	136	166	149	188	180
1953	177	58.7	22.1	21.9	21.7	22.8	59.0	145	183	130	184	197
1954	175	63.1	28.9	19.8	19.5	19.9	54.1	108	158	147	186	177
1955	127	64.1	35.0	18.1	16.3	18.5	70.9	145	206	161	170	173
1956	147	53.2	30.0	21.2	15.7	26.7	60.2	117	202	165	239	229
1957	163	69.8	32.7	20.5	26.9	31.0	45.7	175	192	149	227	257
1958	206	69.7	27.9	15.7	17.2	28.5	63.7	131	244	227	250	182
1959	177	66.5	34.2	23.6	18.7	33.3	53.8	140	179	185	214	233
1960	196	56.0	29.2	17.4	18.1	25.8	56.6	121	186	157	200	187
Average	165	61.3	29.3	19.1	18.7	25.2	57.4	133	186	165	204	201

meeting the Yellowstone River at Huntley, Montana. The U. S. Geological Survey maintained a flow gaging station on Pryor Creek near Billings, Montana, and measured flows at West Buckeye Creek near Billings in 1969. The USGS also maintains two gaging stations on Pryor Creek at and below Pryor, Montana. Flows were determined by the Water Quality Bureau when samples were collected on East Fork Creek, Hay Creek, East Fork of Pryor Creek and Pryor Creek near their respective confluences (see the Water Quality section). These samples were collected by the Water Quality Bureau of the Montana State Department of Health and Environmental Sciences in preparation of this study. Figures 6 and 7 show the monthly mean discharge in cubic feet per second (cfs) for Pryor Creek near Billings, Montana, and at Pryor, Montana. The maximum discharge observed at the Billings station for the period of record was 1700 cfs and the minimum was 0.0 cfs. For the Pryor station the maximum discharge was 468 cfs and the minimum observed was 3.4 cfs. There are numerous diversions for irrigation above both stations which affects the flow (Ref. 26, 28-34). Extensive irrigation along Pryor Creek hinders any general relationships to be drawn from the graphs of Figures 6 and 7. Also, a different set of years is involved in each graph. As is expected the annual high flow on Pryor Creek near Billings is larger than the high flow on Pryor Creek at Pryor. The high flow period seems to occur earlier in the year for the Billings station (February to March) than for the Pryor station (May to June). The peak flow at Pryor seems to be dependent on the snow melt from the Pryor Mountains where as the peak flows near Billings are a result of warming trends in late winter and early spring causing runoff of the low lands in the Pryor Creek drainage. Figure 4 is a schematic diagram of surface waters in the Pryor Creek sub-basin.

YELLOWSTONE RIVER SUB-BASIN - PRYOR CREEK TO BIGHORN RIVER

In this 1520 square mile sub-basin the Yellowstone River flows in a northeasterly direction (Plate I and Fig. 1). There are a couple of perennial and many intermittent streams in this area. Those creeks to the north of the Yellowstone River have small drainage areas and are for the most part intermittent or ephemeral. Geological formations in this segment of the basin do not transmit and store significant quantities of groundwater. Consequently, these streams do not have a sustaining groundwater flow. Flow in these streams is a direct result of snow melt or heavy rains. Some of these creeks are used as return drains for waste irrigation water. Two creeks on the southside of the Yellowstone River in this reach, Fly Creek and Arrow Creek, are perennial. The remaining creeks on this north side are

FIGURE 6.
Table of monthly mean discharge and graph of 6-year average monthly mean discharge in cubic feet per second for Pryor Creek at Pryor, Montana. (Ref. 28)
(These data are for period of record.)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1967	-----	-----	26.8	26.5	25.3	25.6	19.9	23.9	40.2	21.5	8.34	13.
1968	21.1	22.0	23.7	25.5	28.3	24.1	17.7	28.0	43.3	19.5	10.4	21.
1969	29.0	27.1	22.2	20.5	22.5	25.5	25.3	23.0	64.9	46.2	16.9	25.
1970	29.9	31.4	30.5	29.2	29.8	29.9	30.6	136	107	35.2	23.6	29.
1971	37.9	37.9	43.2	40.5	51.5	45.9	46.8	59.4	29.8	19.6	25.4	29.
1972	38.1	38.8	36.3	35.3	43.8	42.9	37.6	48.0	30.4	22.6	24.6	28.
Average	31.2	31.4	30.4	29.6	33.5	32.3	29.6	53.0	52.6	27.4	18.2	24.

FIGURE 7
Table of monthly mean discharge and graph of 4-year average monthly mean discharge in cubic feet per second for Pryor Creek near Billings, Montana. (Ref. 26)
(Data illustrate typical flow.)

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1951	36.5	31.8	31.8	28.3	145	233	50.1	29.9	27.0	9.38	8.63	10.5
1952	24.6	28.8	18.1	22.0	30.5	50.2	37.1	46.3	14.0	12.6	1.03	4.29
1953	9.29	14.7	25.0	34.9	19.1	33.4	28.6	29.9	55.4	0.38	0.87	7.34
1954	16.9	27.6	25.2									
Average	21.8	25.7	25.0	28.4	64.9	105.5	38.6	35.4	32.1	7.45	3.51	7.38

intermittent or ephemeral and exhibit the same flow characteristics as those creeks north of the Yellowstone. Fly Creek and Arrow Creek originate in the rolling foothills between Billings and Hardin (Plate I). There is not much of a base groundwater flow in their upper drainages, but their lower drainage includes a surface water recharge area in the forested hills along the Yellowstone River. Some of the waste irrigation water from the Billings Bench Water Association canal discharges into the Yellowstone River in this area. There is one major water diversion dam on the Yellowstone River in this segment, the Huntley Project diversion dam, which irrigates land on the south side of the Yellowstone River. There are several headgates and numerous pumps for irrigation along the Yellowstone in this reach. Waste irrigation return waters from these irrigation systems empty into the Yellowstone via various drains in this sub-basin and the adjacent Yellowstone sub-basin, Yellowstone River Sub-basin - Bighorn River to Tongue River. There are no active U. S. Geological Survey flow gaging stations in this sub-basin. There is an active station at Billings on the Yellowstone River which is representative of the flow of the Yellowstone in this reach. Flow data are available for Fly Creek near its confluence with the Yellowstone River at Pompeys Pillar, Montana. As was mentioned in the Pryor Creek minor drainage basin, there is some data on Pryor Creek near Billings, Montana. The only flow data on Arrow Creek is that which was obtained when water quality samples were collected by the Water Quality Bureau of the Montana State Department of Health and Environmental Sciences. The sampling station was near Ballantine, Montana (see the Water Quality section). Figures 8, 7, and 9 show the monthly mean discharge and the average monthly mean discharge in cubic feet per second for the Yellowstone River at Billings, Pryor Creek near Billings, and Fly Creek at Pompeys Pillar. From this data, it is apparent that Pryor Creek's and Fly Creek's contribution to the flow of the Yellowstone River is small, usually amounting to less than one percent each. The flow of Arrow Creek is small compared to that of either Pryor Creek or Fly Creek and thus is insignificant to the flow of the Yellowstone.

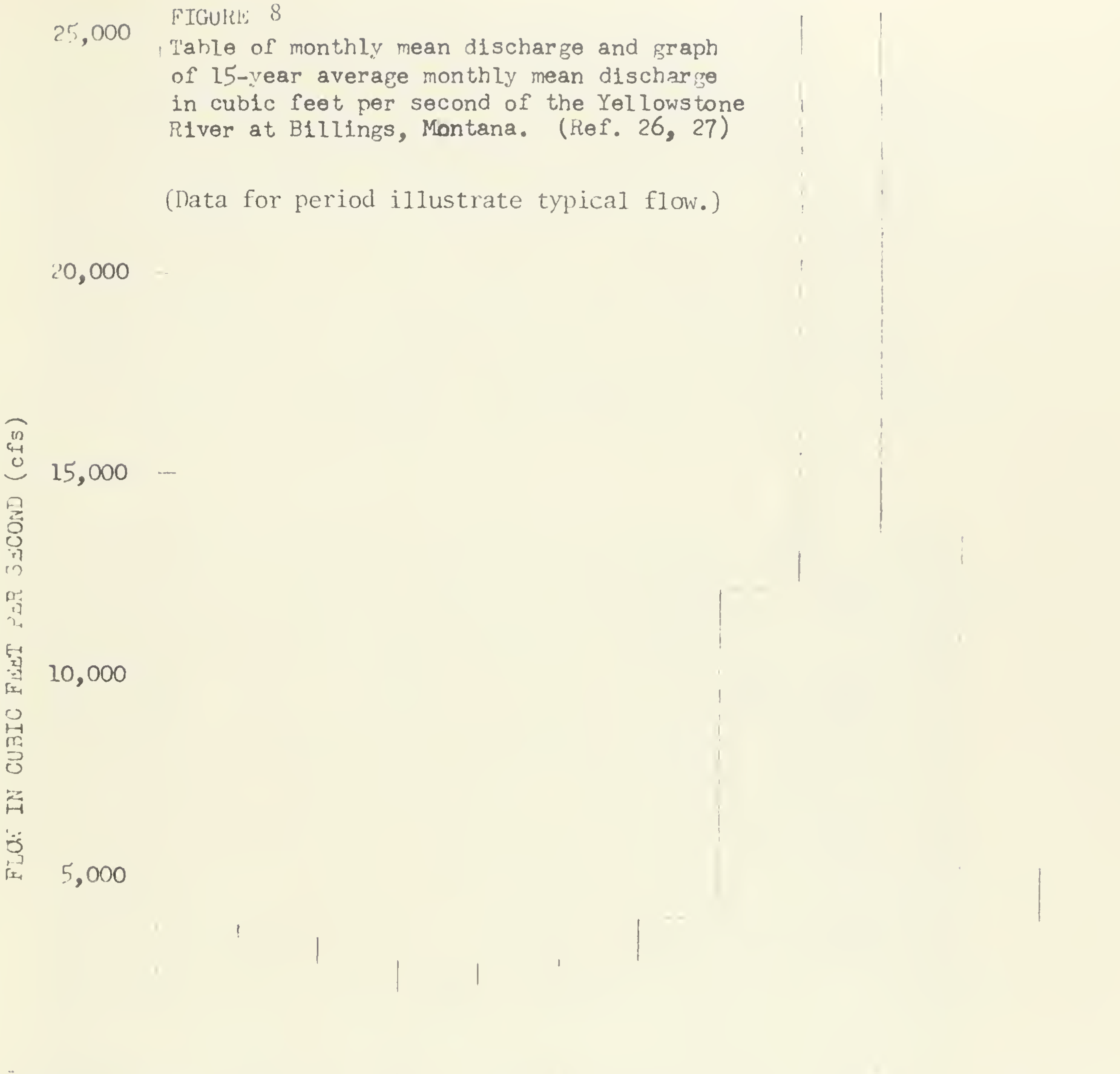
To date the record peak flow on Fly Creek at Pompeys Pillar was 2680 cfs and the recorded low flow was 1.7 cfs (Ref. 28-34). For the Yellowstone River at Billings the peak high flow recorded was 66,100 and the minimum flow recorded was 430 cfs (Ref. 26-34).

Thus, the Yellowstone River provides by far the major surface water in this sub-basin. The graphs of Figures 8, 7,

FIGURE 8

Table of monthly mean discharge and graph of 15-year average monthly mean discharge in cubic feet per second of the Yellowstone River at Billings, Montana. (Ref. 26, 27)

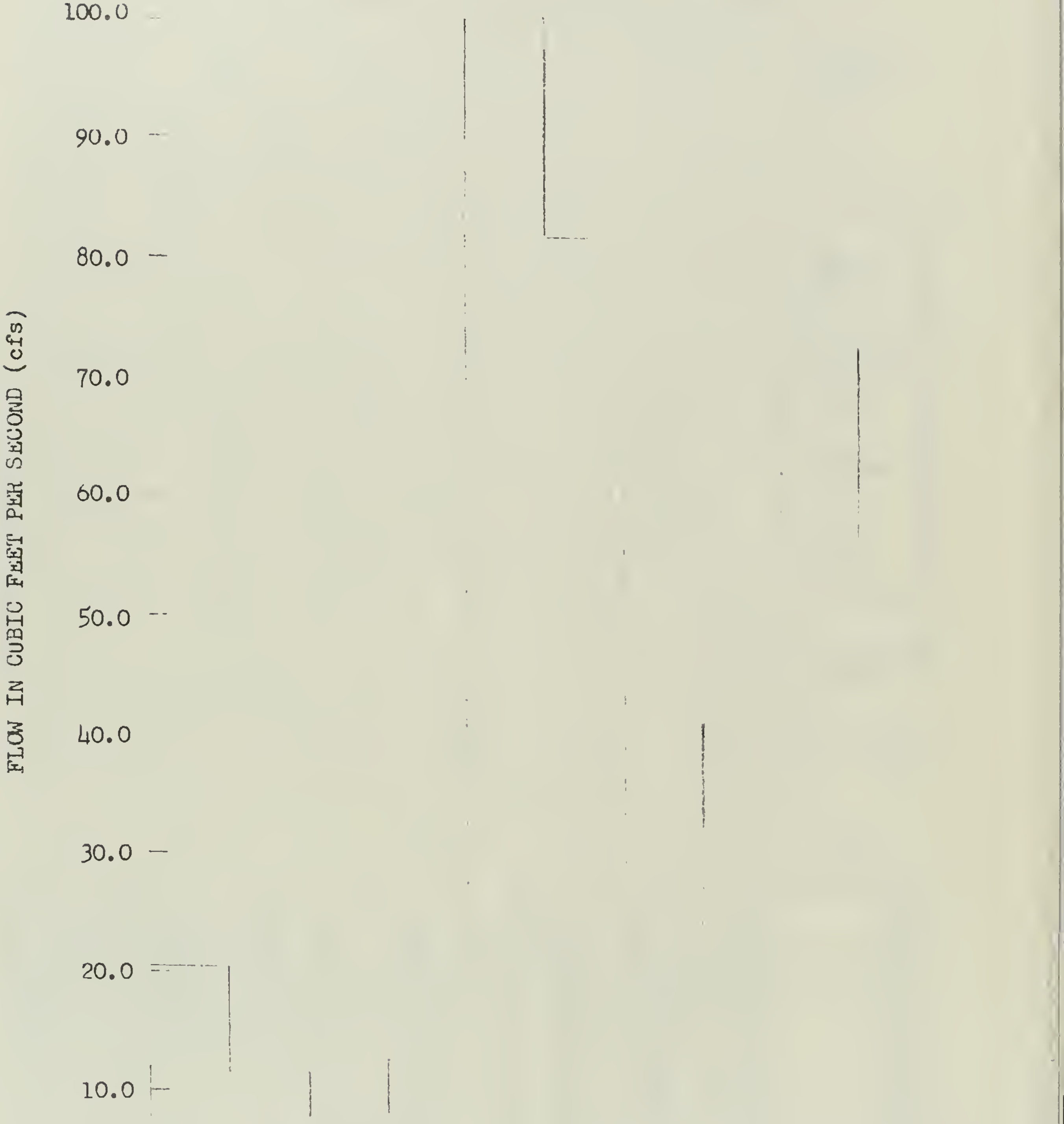
(Data for period illustrate typical flow.)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1951	5338	4847	4007	2799	3550	3752	4574	14870	20980	18250	9672	5346
1952	5098	4431	2948	2634	2726	3027	6882	20350	27370	12310	6088	3721
1953	3065	2938	2658	2777	2512	2419	2804	5635	24900	13960	5269	3190
1954	2759	3124	2766	1964	2682	2253	3351	14040	18430	15760	5208	3230
1955	3035	3091	2549	2168	2041	2313	3982	7645	20310	10300	4040	2695
1956	2996	2792	2758	2595	2509	4056	5215	19960	32400	12360	5557	3714
1957	3056	3486	2837	1622	2555	3023	3151	15910	37940	17830	5326	4783
1958	4246	3904	3108	2465	2408	2569	3044	15800	19390	7825	3828	2957
1959	2714	3272	2835	2273	2229	2892	3631	8407	33020	14800	4578	3442
1960	4275	3841	3112	1911	2403	2886	3531	6756	19920	5924	3408	2360
1961	2655	3008	2425	2192	2380	2016	1438	7110	18980	4970	2232	4790
1962	4999	4542	3146	2352	3973	3476	6039	13330	29290	15150	6843	5091
1963	4010	3590	3002	2149	4098	2642	3080	12890	30340	11300	4015	4155
1964	3243	3333	2468	2355	2631	2412	3402	11650	29060	18960	5809	3852
1965	3068	3402	2998	3397	3320	2806	5146	11350	35250	24080	9425	6888
Average	3637	3573	2908	2377	2801	3023	3951	12380	26500	13580	5420	4014

FIGURE 9
Table of monthly mean discharge and graph of 4-year monthly mean discharge in cubic feet per second for Fly Creek at Pompey's Pillar. (Ref. 28)

(These data are for the period of record.)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SP
1969	24.5	8.49	3.74	4.03	4.76	181	7.91	23.4	115	73.6	30.5	59
1970	22.2	10.1	6.52	6.76	21.4	10.5	8.11	50.6	71.5	45.9	44.2	65
1971	15.9	8.25	5.86	31.5	238	16.7	9.04	39.4	64.0	45.8	51.1	65
1972	19.0	9.61	6.24	4.17	136	121	14.5	56.7	47.9	51.6	67.1	64
Average	20.4	9.11	5.59	11.6	100	82.3	9.89	42.5	74.6	54.2	49.7	64

and 9 show the high flows on Pryor Creek near Billings and Fly Creek at Pompeys Pillar occur during February and March, where as the peak flows for the Yellowstone in this sub-basin occur during the period May through July. This is due to the fact that the runoff from mountain snow pack in the upper basin of the Yellowstone River generally governs its peak flow period, however, the late winter and early spring runoff from snow melt or heavy rains determine peak flow periods for Pryor Creek near Billings and Fly Creek at Pompeys Pillar. It is expected that Arrow Creek's flow features would be similar to those of Fly Creek. Figure 14 is a schematic diagram of surface waters in the Yellowstone River Sub-basin - Pryor Creek to Bighorn River.

LITTLE BIGHORN RIVER SUB-BASIN

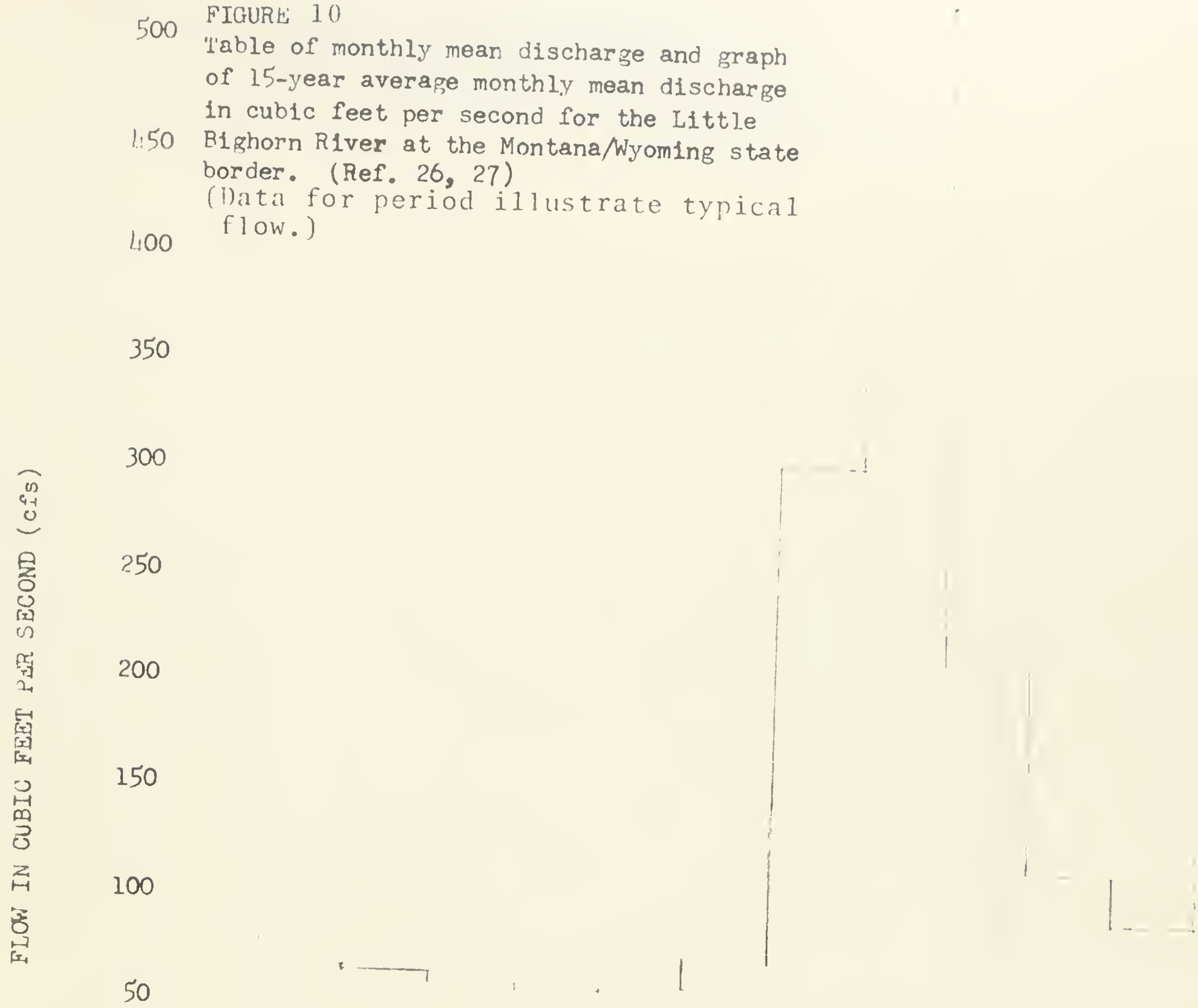
This sub-basin is about 1030 square miles in size. It contains four perennial streams of interest. The Little Bighorn River has the largest drainage with the others, Pass, Lodge Grass, and Owl Creeks, being tributaries. There are several other creeks which have very small, if any, base groundwater flow and their respective drainage areas are very small (Plate I, Fig. 1). The Little Bighorn River originates in the northeastern section of the Bighorn Mountains in Wyoming. In its upper drainage, above the confluence of Pass Creek, it is fed by many springs and small creeks. For two of these creeks within Montana, Ed's Creek and Spring Creek, there is some flow data collected by the U. S. Geological Survey (Ref. 26 and 27). In this portion of the Little Bighorn River's drainage, the river flows northeasterly turning north at the confluence of Pass Creek near Wyola, Montana. From Pass Creek downstream the Little Bighorn flows generally northward entering the Bighorn River near Hardin, Montana. The U. S. Geological Survey maintains flow gaging stations on the Little Bighorn River at the Montana/Wyoming border, below Pass Creek near Wyola, and upstream from its mouth near Hardin. They had maintained a station near Crow Agency and have collected sporadic flow data from several other places along the river. Pass Creek originates in the eastern slopes of the Bighorn Mountains in Wyoming. In Montana it flows mostly northward emptying into the Little Bighorn River near Wyola. There are no active U. S. Geological Survey flow gaging stations on Pass Creek. The Survey had maintained a flow gaging station on Pass Creek near Wyola. Flow data were measured in Pass Creek when water quality samples were collected by the Water Quality Bureau as part of this study.

Lodge Grass Creek begins in the northeastern section of the Bighorn Mountains in Montana just west-northwest of the

Little Bighorn River drainage. In this area the creek is fed by several springs and small streams. It flows generally northeastward meeting the Little Bighorn River at Lodge Grass, Montana. The Willow Creek dam or the Lodge Grass Storage Reservoir is tributary to Lodge Grass Creek and provides for flood control, water for irrigation, and recreation. The reservoir is located in the middle of the Lodge Grass Creek drainage separating the upper and lower reaches. The U. S. Geological Survey maintains a flow gaging station on Lodge Grass Creek about one-half mile upstream from Willow Creek diversion canal. Stream flow was measured in Lodge Grass Creek at Lodge Grass, Montana, when water quality samples were collected by the Water Quality Bureau (see the Water Quality section). Figures 10, 11, 12, 13, and 14 show monthly mean discharges and a graph of an average monthly mean discharge in cubic feet per second for the Little Bighorn River at the Montana/Wyoming state line; Pass Creek near Wyola, Montana; Little Bighorn River below Pass Creek near Wyola, Montana; Lodge Grass Creek above Lodge Grass Storage Reservoir near Wyola, Montana; and Little Bighorn River upstream from its mouth near Hardin. For the Little Bighorn River at the state line near Wyola, the maximum flow record was 2,730 cfs and the minimum was 21 cfs. The maximum recorded flow for Pass Creek near Wyola was 1150 cfs and the minimum was 0.0 cfs. For the Little Bighorn River below Pass Creek near Wyola the maximum recorded has been 3630 cfs and the minimum has been 12 cfs. The maximum recorded discharge for Lodge Grass Creek above the Willow Creek diversion near Wyola has been 1130 cfs and the minimum has been 3 cfs. For the Little Bighorn River near Hardin the maximum recorded discharge has been 4520 cfs and the minimum has been 0.2 cfs. There are numerous headgates and pumps diverting water for irrigation from these streams which affects the flow of the Little Bighorn River from the state line to its confluence. Pass Creek supplies a significant amount of flow to the Little Bighorn River but usually no more than 30%. Both Lodge Grass Creek and Owl Creek contribute a significant amount to the total flow of the Little Bighorn River but the net contribution of these streams has not been determined. The Little Bighorn River seems to provide the major portion of water in this sub-basin.

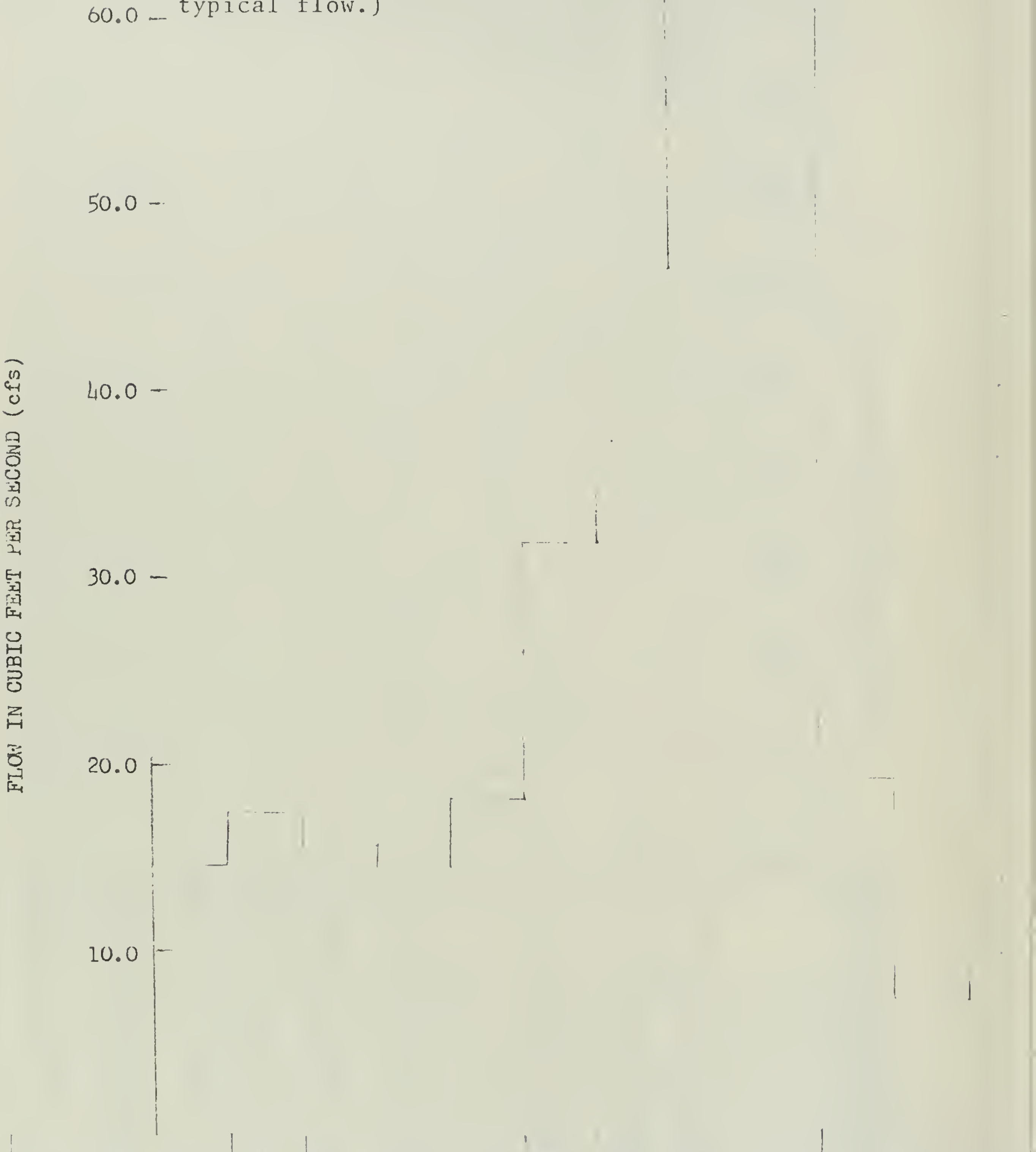
The peak flow period for all the stations on the Little Bighorn River occurs in June due to snow melt in the upper drainage. Lodge Grass Creek also displays a June peak flow period due to its extensive upper drainage in the Bighorn Mountains. The peak discharge period for Pass Creek occurs somewhat early in May, which may be attributed to the amount of drainage area of Pass Creek on the slopes of the mountains, low lands, and rolling hills. Figure 4 is a schematic diagram of surface waters in the Little Bighorn River Sub-basin.

FIGURE 10
Table of monthly mean discharge and graph of 15-year average monthly mean discharge in cubic feet per second for the Little Bighorn River at the Montana/Wyoming state border. (Ref. 26, 27)
(Data for period illustrate typical flow.)



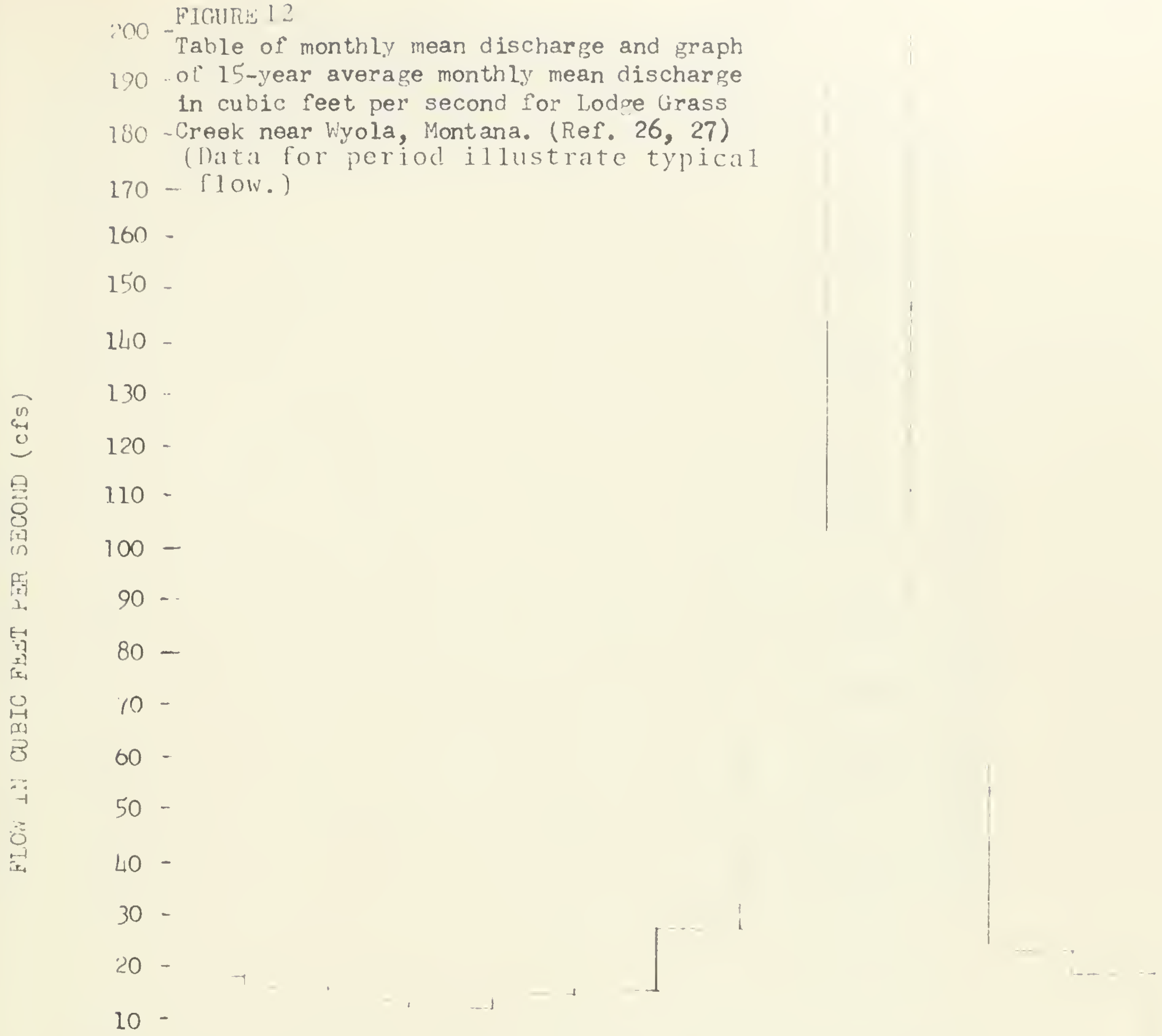
Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1951	76.5	70.1	62.7	60.9	50.1	54.1	66.4	303	367	231	133	93.3
1952	84.5	74.6	65.5	62.2	58.3	56.0	130	422	324	160	107	80.9
1953	70.3	58.9	61.4	60.4	54.5	59.2	60.1	127	619	179	105	82.4
1954	71.9	64.7	62.4	54.8	54.1	54.0	69.8	316	377	172	88.7	74.5
1955	69.8	60.8	54.9	50.5	56.4	53.9	69.7	326	491	203	106	80.7
1956	72.9	61.1	58.0	54.0	53.5	54.5	61.0	299	317	130	91.1	77.0
1957	67.3	60.5	57.5	49.5	52.5	52.6	59.1	228	724	285	154	115
1958	99.1	83.2	71.5	61.1	55.3	58.2	63.5	382	250	139	97.3	79.4
1959	70.2	66.0	60.6	56.5	57.9	57.2	65.9	182	687	219	118	89.6
1960	82.4	69.5	64.5	57.2	51.8	54.7	71.5	186	266	118	86.7	69.4
1961	64.0	57.2	52.3	50.5	52.3	48.6	50.7	212	256	101	69.8	67.9
1962	64.5	58.9	51.7	48.3	50.4	53.0	119	331	402	193	115	86.1
1963	72.1	68.0	56.5	43.6	60.5	57.1	69.7	407	788	242	128	99.2
1964	85.5	75.5	63.3	66.2	65.6	66.5	81.1	429	961	405	171	129
1965	108	91.8	85.6	74.7	66.8	61.4	85.9	314	927	337	149	122
Average	77.3	68.0	61.9	56.7	56.0	56.1	71.3	298	517	208	114	89.8

FIGURE 11
Table of monthly mean discharge and graph of 6-year average monthly mean discharge in cubic feet per second for Pass Creek near Wyola, Montana. (Ref. 26)
(Data for period illustrate typical flow.)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1951	12.2	19.9	16.1	14.8	17.7	55.0	20.9	42.4	38.7	33.5	14.5	13.7
1952	19.9	24.6	13.8	11.4	16.5	40.2	80.2	90.1	39.7	18.5	7.32	11.3
1953	12.6	13.2	15.8	14.3	10.8	24.1	23.2	54.5	93.2	18.1	7.18	8.2
1954	8.57	16.2	19.9	20.7	34.2	18.4	41.6	65.2	56.4	12.2	3.40	4.
1955	5.73	14.3	15.5	11.4	13.4	18.1	83.9	81.0	86.8	22.8	6.76	9.3
1956	14.2	15.6	13.3	14.7	15.7	33.2	27.6	57.9	47.7	8.81	2.67	7.3
Average	14.6	17.3	15.7	14.6	18.1	31.5	46.2	65.2	60.4	19.0	6.97	9.

FIGURE 12
Table of monthly mean discharge and graph of 15-year average monthly mean discharge in cubic feet per second for Lodge Grass Creek near Wyola, Montana. (Ref. 26, 27) (Data for period illustrate typical flow.)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1951	17.5	15.9	14.7	13.8	15.2	17.7	16.5	83.2	117	64.4	32.7	22.1
1952	20.3	17.5	16.0	16.3	13.3	18.2	31.2	134	110	37.9	23.2	18.3
1953	15.8	12.9	13.6	15.3	10.2	14.1	16.8	42.7	204	50.2	23.5	16.9
1954	15.8	17.1	17.9	12.6	16.8	14.9	27.0	86.5	110	45.2	17.6	12.7
1955	14.2	13.5	10.9	8.87	9.68	11.0	42.3	89.3	152	56.4	21.8	15.8
1956	14.5	13.2	11.5	12.7	11.8	19.0	17.2	95.4	117	27.6	14.9	11.7
1957	13.4	13.2	10.9	9.16	14.7	11.9	24.8	93.7	356	81.6	37.3	27.4
1958	23.6	20.6	17.0	14.4	13.6	15.0	18.6	203	108	42.3	22.6	17.0
1959	17.5	16.9	16.6	11.7	13.4	21.3	21.5	53.5	317	60.5	25.2	19.4
1960	19.5	17.7	16.6	15.7	12.4	28.1	18.9	61.3	78.9	24.1	15.8	8.11
1961	11.5	10.7	9.19	9.97	9.74	10.4	12.6	57.0	86.1	20.1	10.3	14.0
1962	12.9	12.8	10.6	11.7	16.8	13.6	35.5	113	145	50.5	22.3	17.1
1963	15.1	14.8	13.3	10.5	21.3	13.6	51.0	188	345	66.8	27.0	22.3
1964	19.2	17.2	15.1	16.3	15.0	17.0	45.7	147	445	176	43.3	40.1
1965	30.3	26.4	24.0	22.2	25.6	23.7	55.5	109	317	89.4	35.0	29.9
Average	17.4	16.0	14.5	13.4	14.6	16.6	29.0	104	200	59.5	24.8	19.5

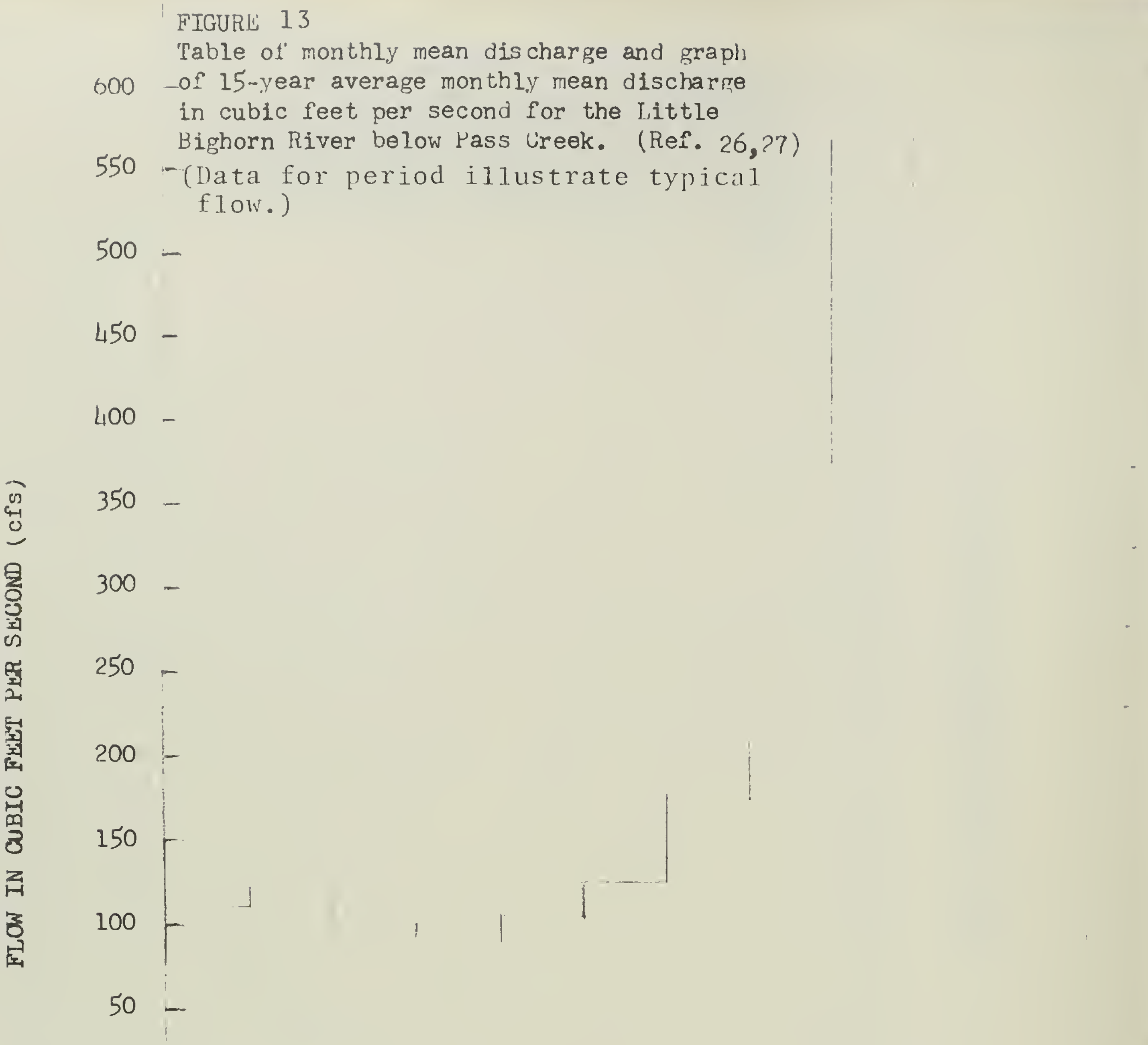
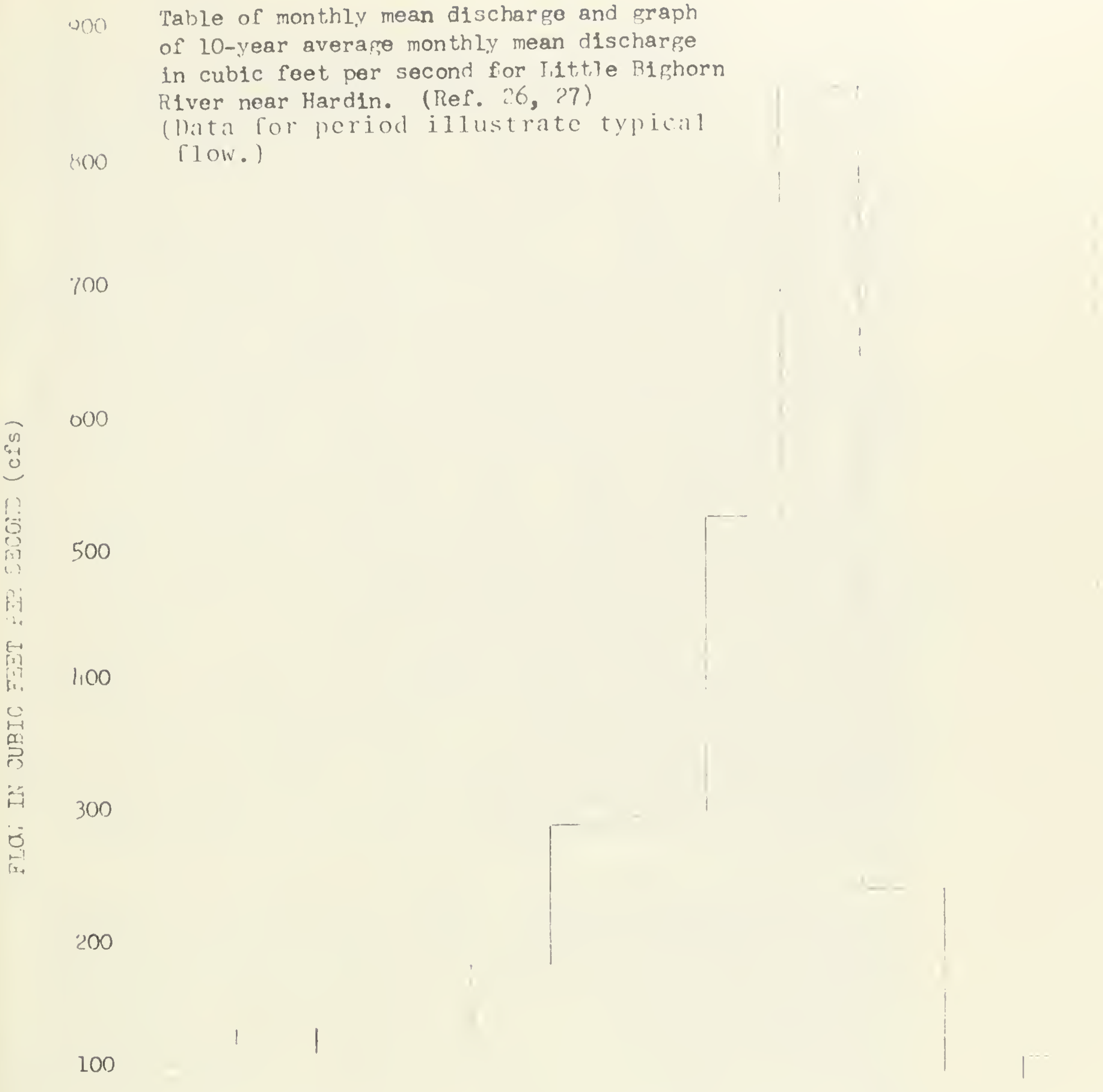


FIGURE 13
Table of monthly mean discharge and graph of 15-year average monthly mean discharge in cubic feet per second for the Little Bighorn River below Pass Creek. (Ref. 26,27)
(Data for period illustrate typical flow.)

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1951	112	106	101	100	100	154	108	268	421	267	134	113
1952	140	133	91.3	66.3	94.5	154	240	472	348	135	89.0	84.9
1953	108	104	106	104	96.4	98.8	89.7	146	633	141	85.8	77.2
1954	86.8	106	104	84.7	99.5	96.2	131	356	350	123	70.6	61.8
1955	94.8	93.4	79.8	71.6	77.1	92.2	270	411	502	166	57.7	67.0
1956	100	104	100	93.4	109	163	125	363	344	87.4	59.5	69.7
1957	79.4	120	97.5	78.4	105	103	152	389	1092	330	126	142
1958	140	131	120	104	107	105	118	445	292	158	84.0	60.1
1959	97.5	118	121	----	----	----	----	---	----	----	62.4	75.7
1960	122	126	111	86.3	91.9	210	122	158	203	57.4	44.4	54.9
1961	88.8	92.5	87.2	86.5	90.2	76.9	63.1	162	201	58.2	23.8	84.5
1962	109	106	85.1	94.7	132	107	201	341	485	205	95.0	102
1963	123	109	95.4	78.4	230	102	261	652	1172	240	116	98.4
1964	103	126	105	107	103	118	281	607	1322	464	177	[illegible]
1965	154	152	162	153	189	135	239	482	1023	355	136	163
Average	110	115	104	93.6	116	122	171	375	507	199	90.7	94.0

FIGURE 14.
Table of monthly mean discharge and graph of 10-year average monthly mean discharge in cubic feet per second for Little Bighorn River near Hardin. (Ref. 26, 27)
(Data for period illustrate typical flow.)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1956	112	130	124	110	128	412	212	389	377	45.0	27.4	61.2
1957	67.6	129	104	89.9	266	213	282	450	1422	418	117	179
1958	163	168	142	134	135	142	133	328	376	138	70.8	40.3
1959	113	135	130	118	98.4	503	224	286	712	181	110	117
1960	140	150	124	110	120	477	164	116	165	26.8	12.7	19.1
1961	78.0	95.3	84.8	86.9	106	92.7	54.8	71.9	117	8.5	216	51.2
1962	113	115	68.7	82.1	221	197	255	347	532	164	77.1	117
1963	127	114	95.6	80.9	254	174	360	824	1498	242	96.7	122
1964	97.4	145	126	121	122	144	506	841	1873	718	242	215
1965	189	150	152	223	346	535	748	668	1411	441	160	193
Average	120	133	115	116	180	289	294	532	848	238	91.6	112

BIGHORN RIVER SUB-BASIN

Since November 1965 the flow of the Bighorn River in Montana has been regulated by Yellowtail Reservoir. The data and discussion presented here on this sub-basin concerns the surface water of the Bighorn River system of Montana after regulation by Yellowtail Reservoir. This sub-basin contains approximately 2380 square miles in Montana. This area includes that part of Yellowtail Reservoir in Montana (Plate I and Figure 1). Crooked Creek, Porcupine Creek, Dry Head Creek, Hoodoo Creek, Big Bull Elk Creek, Little Bull Elk Creek, and Black Canyon Creek all flow into Yellowtail Reservoir. With the exception of Hoodoo and Little Bull Elk Creeks, there is some flow data available from the U. S. Geological Survey. Crooked Creek flows south out of the Pryor Mountains, enters Wyoming, and turns east emptying into Yellowtail near Lovell, Wyoming. The U. S. Geological Survey flow data for Crooked Creek is available for December 1964 to September 1965. The maximum discharge during this period was 1460 cfs and the minimum was 1.2 cfs (Ref. 27). The origin of Porcupine Creek is in the Bighorn Mountains. It flows down through Devil's Canyon and enters Yellowtail Reservoir near the Montana/Wyoming border. Flow data is available for Porcupine Creek from the U. S. Geological Survey for November 1964 to September 1965. During this period, maximum discharge recorded was 1000 cfs and the minimum 5.5 cfs (Ref. 27). Dry Head Creek originates in the northeast portion of the Pryor Mountains, flowing east to Yellowtail Reservoir. The U. S. Geological Survey measured flows in this stream at a station about 23 miles southeast of Pryor, Montana, from October 1965 until September 1967. The maximum flow recorded during this period was 1060 cfs; the minimum was 4.0 cfs (Ref. 27). From December 1964 until September 1965 the U. S. Geological Survey maintained a flow gaging station on Dry Head Creek about 5.5 miles upstream from the previously described station. Big Bull Elk Creek originates in the Bighorn Mountains of Montana and flows generally northwest through Big Bull Elk Canyon to Yellowtail Reservoir. The data available from the U. S. Geological Survey for this stream is for November 1964 to December 1967. During this period the recorded maximum discharge was 210 cfs and the minimum was 8.4 cfs (Ref. 27 and 28). The source of Black Canyon Creek is also in the Bighorn Mountains of Montana. The creek flows generally northwest to Yellowtail Reservoir through Black Canyon. The U. S. Geological Survey maintained two flow gaging stations on this creek. One was approximately 1.5 miles upstream from the Yellowtail Reservoir flow line. The period of record for this station was October 1965 to December 1967. The other was located about 7 miles upstream from the reservoir flow line, and the period of record was October 1964 to September 1966. The maximum flow was recorded at the lower station and was 1100 cfs. The minimum was recorded at the upper station and was 19 cfs (Ref. 27 and 28). Flow measurements were obtained for all the streams, including Hoodoo and Little Bull Elk Creeks, when water quality samples were collected by the Water Quality Bureau (see Water Quality section). Figure 15 shows the monthly mean discharge and a graph of the average monthly mean discharge in cubic feet per second (cfs) for the Bighorn River near St. Xavier for the six-year period (October 1967 - September 1972) since the flow has been regulated by Yellowtail Reservoir. The U. S. Geological Survey flow gaging station from which this data was obtained is located below the afterbay diversion dam at Yellowtail Reservoir; but the flow is both that of the Bighorn River and the Bighorn irrigation canal. There are two small creeks which flow into the river between the reservoir discharge and the gaging station, Grapevine Creek and Lime Kiln Creek. Both of these creeks have relatively small drainages and their flows seem to be generally insignificant in relation to the flow from the reservoir. Thus, the flow data of Figure 15 should be representative of the discharge from the reservoir. The maximum recorded discharge at this station since regulation started has been 24,800 cfs and the minimum has been 112 cfs. These both occurred in water year 1967 and each subsequent year has shown lower maximums and higher minimums. High annual monthly mean discharges generally occur in June and July, with those in July being slightly higher. August through November is the period of lowest flows.

There are three major perennial streams (Soap Creek, Beauvais Creek, and the Little Bighorn River) and two ephemeral streams (Rotten Grass Creek and Tullock Creek) which enter the Bighorn River between the flow gaging station near St. Xavier, Montana, and the flow gaging station at Bighorn, Montana. Soap Creek originates on the northeastern slopes of the Bighorn Mountains in Montana. The creek flows generally northward entering the Bighorn River about 4.5 miles below the Bighorn River gaging station near St. Xavier (Plate I). Figure 16 shows typical monthly mean discharge and a graph of average monthly mean discharge in cubic feet per second (cfs) for Soap Creek near its mouth near St. Xavier. The graph shows the high monthly mean discharge month to be May with significant discharges occurring in February. This is consistent with a stream that has both a mountainous snow pack runoff and a prairie runoff. There is additional U. S. Geological Survey flow data available for the period 1939-1953. The maximum recorded discharge for the period of record has been 2980 cfs and minimum has been 1.0 cfs. The flow of Soap Creek generally amounts to less than 5% of the flow of the Bighorn River in this area (Ref. 20). Rotten Grass Creek, also, originates on the northeastern slopes of the Bighorn Mountains in Montana. In its upper drainage, the creek flows northeastward turning to the north-northwest in its lower drainage and finally discharges to the Bighorn River near St. Xavier. Figure 17 shows monthly mean discharge and a graph of average monthly mean discharge in cubic feet per second for Rotten Grass Creek near its mouth near St. Xavier. Like Soap Creek, Rotten Grass Creek has both a mountainous drainage and a prairie drainage. The graph of Figure 19 is characteristic of this type of drainage with May being the high water month but significant high flows occurring in March. The average monthly mean flows during the high water month for Rotten Grass Creek are about the same as those for Soap Creek, but because of Rotten Grass Creek's ephemeral nature, monthly mean low flows are lower than for Soap Creek. The recorded maximum flow for Rotten Grass Creek has been 688 cfs and the minimum is 0.0 cfs. The flow of Rotten Grass Creek is usually less than 5% of the flow of the Bighorn River in this reach (Ref. 28). Stream flow was measured when water quality samples were collected on Soap Creek and Rotten Grass Creek by the Water Quality Bureau (see the Water Quality section). Beauvais Creek has its source on the northeastern slopes of the Pryor Mountains. The creek flows generally eastward entering the Bighorn River near St. Xavier. There is an active U. S. Geological flow gaging station located about 14 miles upstream from the confluence of Beauvais Creek and the Bighorn River. The location of this station is in an area in which the drainage of Beauvais Creek changes from a mountain slope to a prairie (Plate I). Figure 18 shows monthly mean discharges and a graph of an average monthly mean discharge in cubic feet per second for Beauvais near St. Xavier. As the graph shows, high monthly mean flows occur in May which is consistent with the type of drainage area above the gaging station. The maximum recorded discharge for Beauvais Creek at this station has been 1600 cfs and the lowest flow has been 0.50 cfs. Although no data has been found for the flow of Beauvais Creek at its mouth, the flow is suspected to be generally less than 5% of the flow of the Bighorn River in this area (Ref. 28). The flow from Soap, Rotten Grass, and Beauvais Creeks probably adds a significant amount to the flow of the Bighorn River below St. Xavier, especially in May. The U. S. Geological Survey maintained a flow gaging station on the Bighorn River at Hardin, but this was before the regulation of flow by Yellowtail Reservoir. The Little Bighorn River combines with the Bighorn River just north of

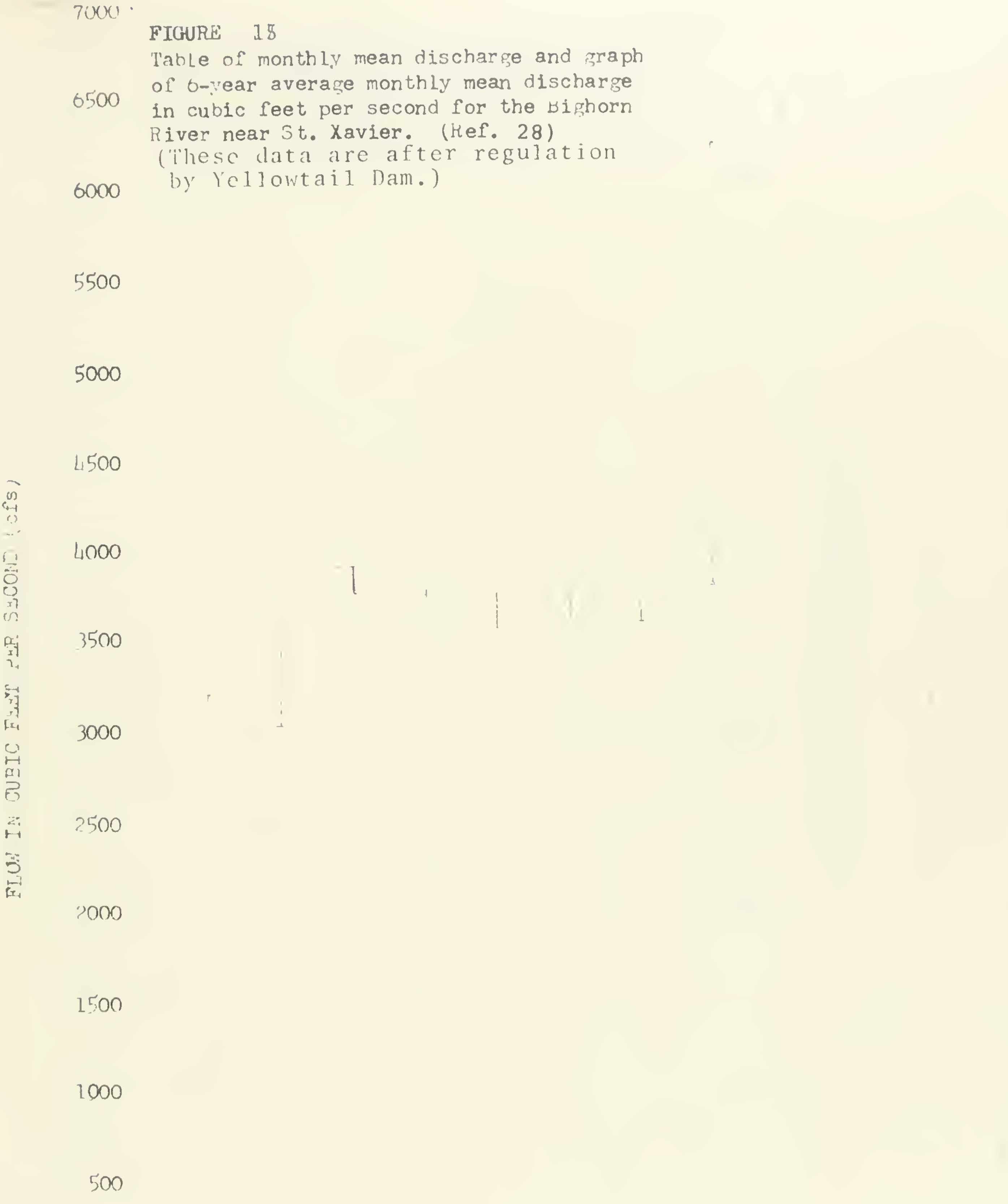
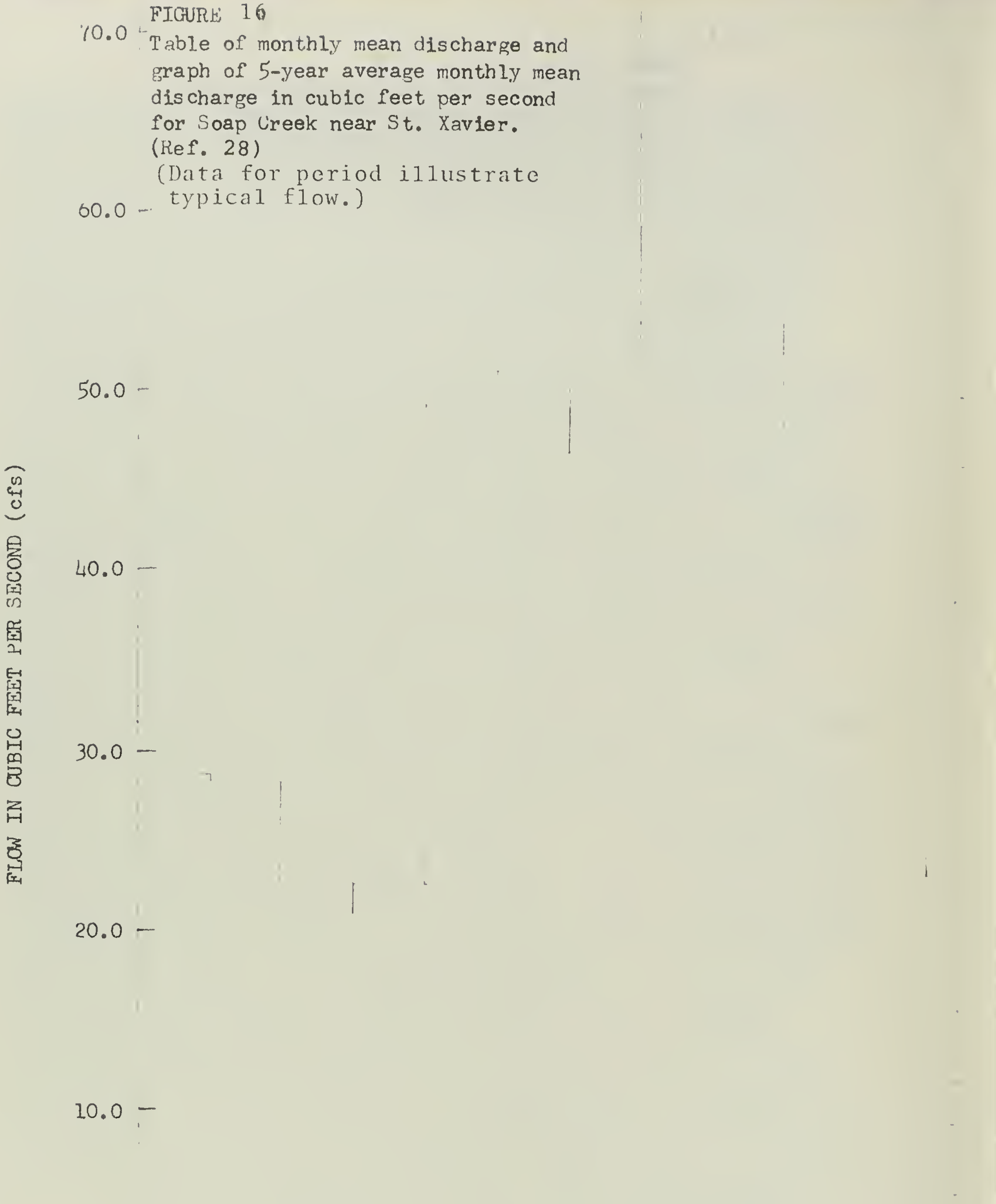


FIGURE 15
Table of monthly mean discharge and graph of 6-year average monthly mean discharge in cubic feet per second for the Bighorn River near St. Xavier. (Ref. 28)
(These data are after regulation by Yellowtail Dam.)

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1967	1363	1757	2435	1903	2215	2640	2326	2368	7019	18890	4227	3021
1968	3141	3596	4999	5267	4092	4355	3622	4209	8387	2883	2320	3768
1969	3557	4129	3939	3618	3783	4266	2181	1668	3104	4777	3578	3251
1970	3393	3087	3837	3968	3788	2088	1144	2377	5410	6770	2520	1972
1971	2571	3159	4014	3813	3538	4553	5541	6985	7962	5975	3347	2594
1972	5142	5073	4236	3999	4000	4615	6675	5055	6134	3932	3225	3144
Average	3194	3017	3910	3761	3569	3753	3582	3777	6336	7204	3203	2958

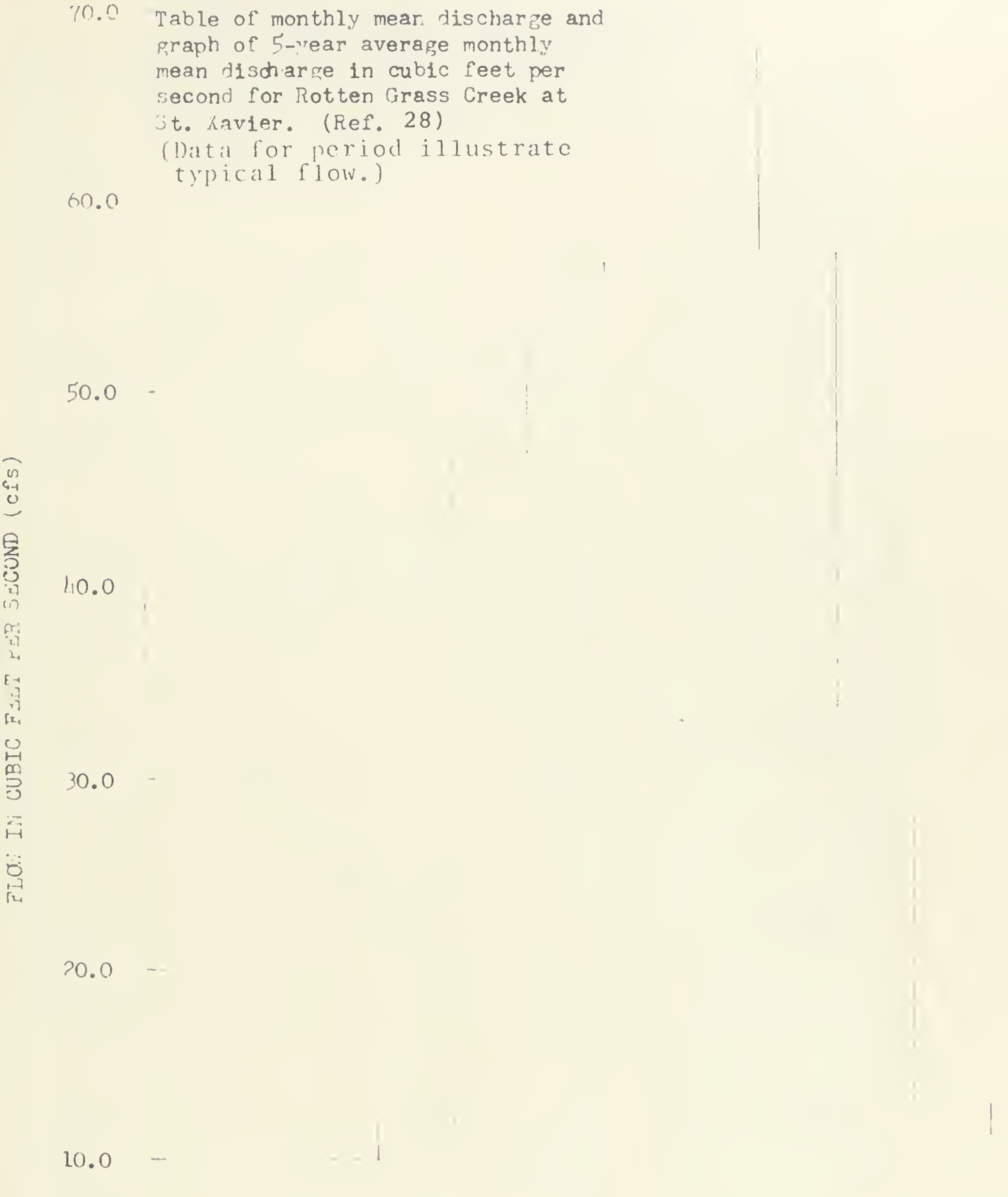
FIGURE 16

Table of monthly mean discharge and graph of 5-year average monthly mean discharge in cubic feet per second for Soap Creek near St. Xavier. (Ref. 28)
(Data for period illustrate typical flow.)



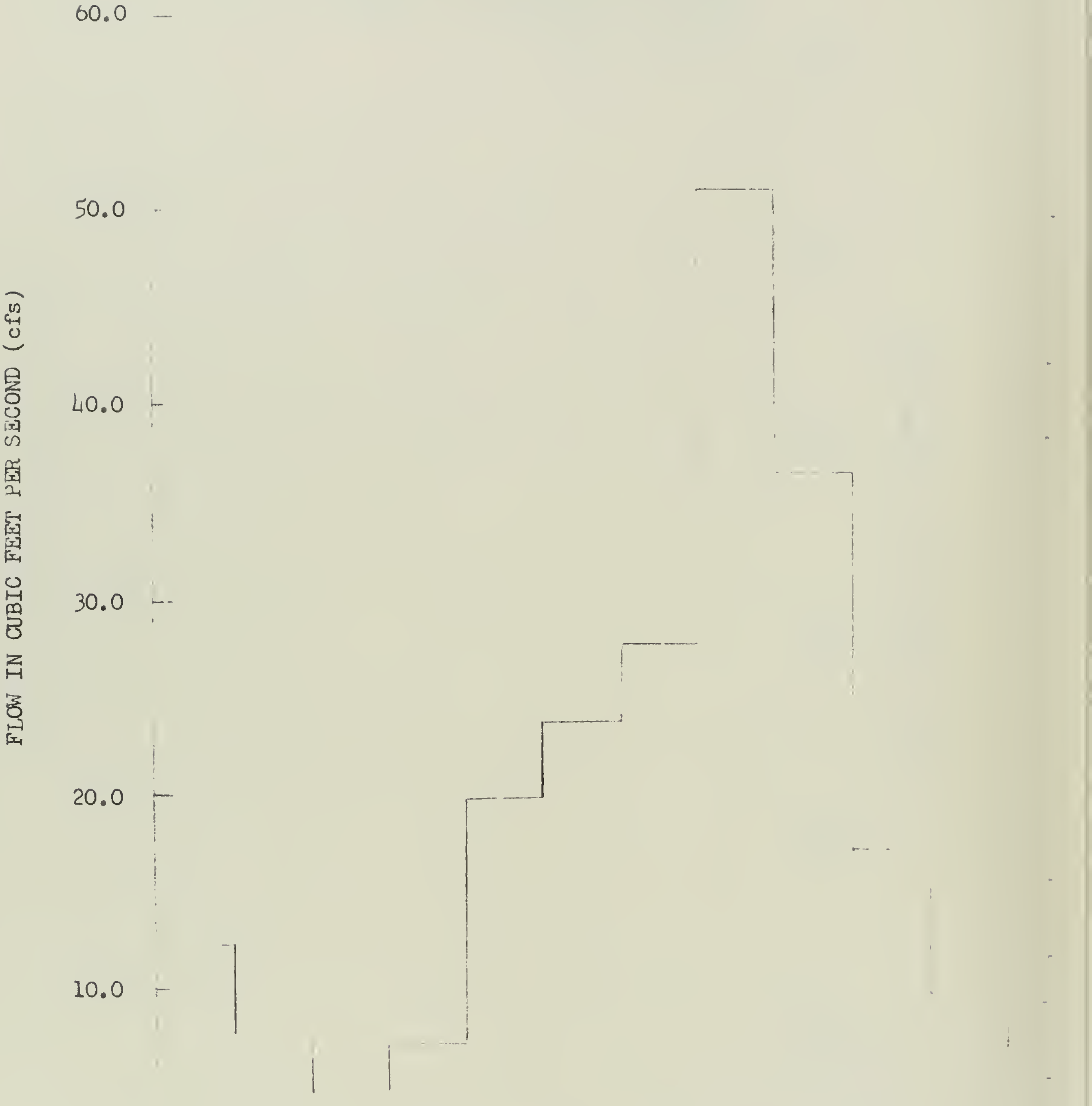
Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1968	24.0	24.5	16.3	19.6	38.2	38.6	35.6	45.4	68.2	29.7	24.6	24.8
1969	24.2	27.2	24.6	19.5	21.3	41.9	39.4	34.4	67.5	45.3	21.7	20.7
1970	25.4	26.9	21.1	23.7	36.9	49.5	82.1	187	68.7	38.5	27.9	30.3
1971	32.5	31.6	23.1	29.4	61.8	36.4	57.5	48.8	33.1	26.2	18.5	24.8
1972	37.5	31.9	18.8	21.2	96.2	65.0	40.3	42.1	31.2	24.3	23.2	21.1
Average	28.7	28.4	20.8	22.7	50.9	46.3	51.0	71.5	53.7	32.8	23.2	24.

FIGURE 17
Table of monthly mean discharge and graph of 5-year average monthly mean discharge in cubic feet per second for Rotten Grass Creek at St. Xavier. (Ref. 28)
(Data for period illustrate typical flow.)



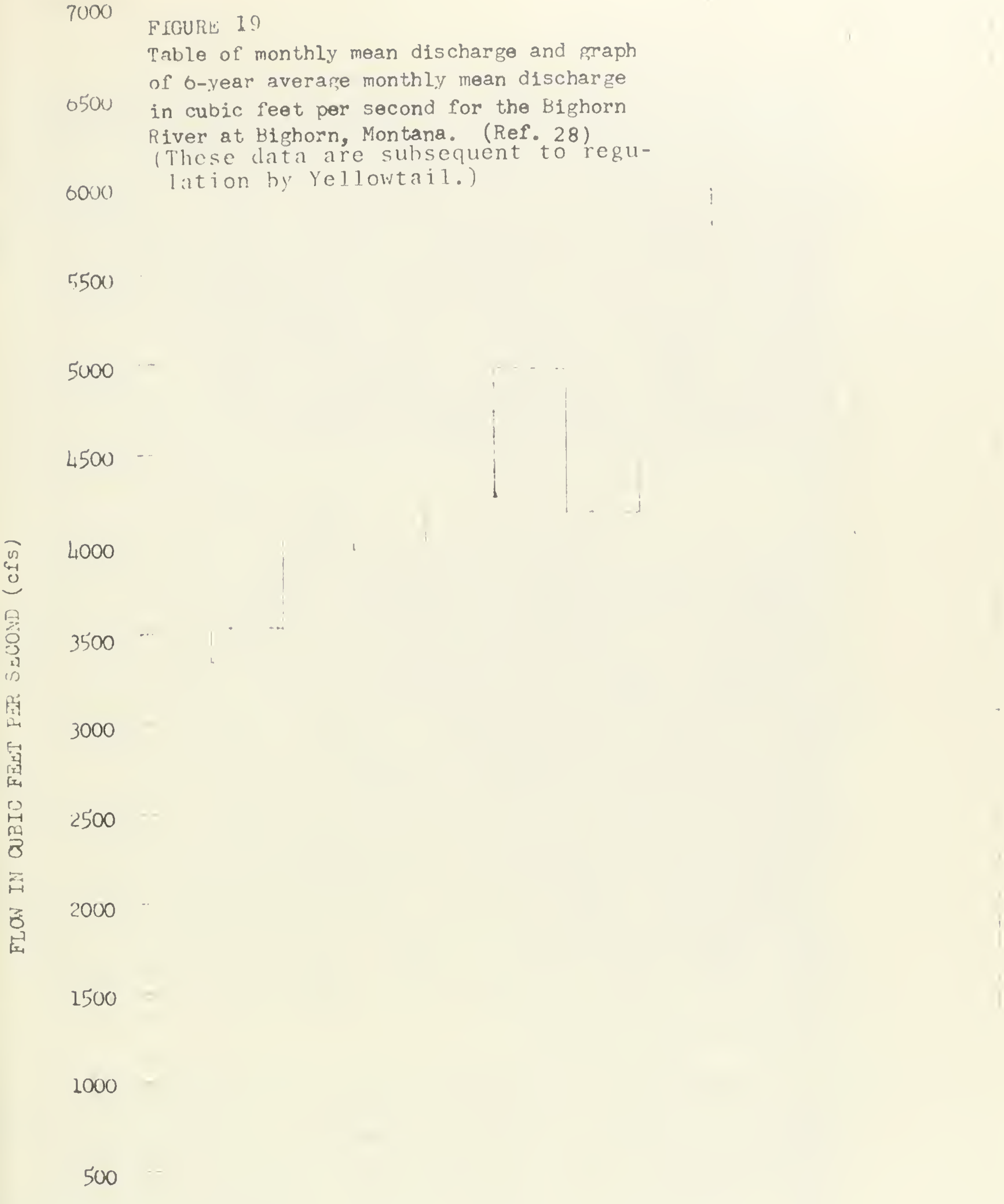
Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1968	8.56	8.70	7.69	11.1	38.6	29.9	22.4	42.8	84.5	23.4	14.0	12.0
1969	10.7	11.3	9.18	7.66	7.00	57.5	32.6	40.2	51.4	49.9	14.7	11.4
1970	10.9	12.6	9.82	11.4	21.8	48.2	65.4	184	89.6	30.8	16.5	16.0
1971	15.7	14.9	12.3	17.6	68.5	52.0	52.2	54.9	33.2	18.0	9.63	10.3
1972	13.9	12.5	11.9	11.8	108	95.6	30.8	48.6	25.9	15.9	10.6	8.70
Average	12.0	12.0	10.2	11.9	48.8	56.6	40.7	74.1	56.9	27.6	13.1	11.7

FIGURE 18
Table of monthly mean discharge and graph
of 6-year average monthly mean discharge
in cubic feet per second for Beauvais Creek
near St. Xavier. (Ref. 28) (These data are for period of recor



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1968	6.97	6.99	5.59	9.48	15.4	11.8	9.65	23.1	49.3	6.21	5.65	4.95
1969	3.95	5.91	4.39	4.01	3.21	15.0	18.8	14.3	55.4	42.6	5.79	3.99
1970	5.48	6.49	3.27	4.53	5.81	12.4	28.1	121	42.9	17.7	10.1	10.4
1971	8.34	7.54	5.96	11.4	27.4	18.7	34.9	36.4	17.3	8.73	5.38	7.36
1972	36.2	12.1	4.11	5.89	47.3	60.9	47.8	59.5	17.3	10.3	20.7	6.59
Average	12.2	7.81	4.66	7.06	19.8	23.8	27.8	50.9	36.4	17.1	9.52	6.66

FIGURE 19
Table of monthly mean discharge and graph of 6-year average monthly mean discharge in cubic feet per second for the Bighorn River at Bighorn, Montana. (Ref. 28)
(These data are subsequent to regulation by Yellowtail.)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1967	1458	1829	2445	1971	2312	2917	2379	2907	8223	19090	3951	3013
1968	3309	3808	4907	5478	4655	4983	4035	4490	10680	3011	2491	3805
1969	3612	4353	4134	3708	4020	5998	3068	2584	4132	5440	3384	3295
1970	3479	3262	3852	4130	4210	3022	2104	4585	7154	6927	2327	2189
1971	2817	3409	4117	4367	5314	6000	6285	7497	8763	5671	3223	2841
1972	5546	5352	4443	4017	4906	6580	7203	5810	6369	3953	3201	3299
Average	3370	3669	3983	3945	4236	4917	4179	4646	7554	7349	3096	3074

Hardin (Plate I). The flow of the Little Bighorn usually amounts to less than 15% of the flow of the Bighorn River, but this can be a significant amount especially in June (see sub-section "Little Bighorn River Sub-Basin"). Tullock Creek is the major stream entering the Bighorn River between Hardin and Bighorn. The creek originating in the forested, rolling hills between Hardin and Busby flows generally north-northwest meeting the Bighorn River about 1.5 miles upstream from the confluence of the Bighorn and Yellowstone Rivers (Plate I). The total drainage area of Tullock Creek is basically one of a prairie. This would indicate that high monthly mean flows should occur in late winter or early spring. Tullock Creek has a relatively large drainage area and high flows are probably similar to those for Soap Creek, Rotten Grass Creek, and Beauvais Creek. Due to the creeks' ephemeral nature and significant diversions for irrigation, there are probably more periods of no flow for Tullock Creek than for Rotten Grass Creek. The only flow data available seems to be that obtained by the Water Quality Bureau during water quality sampling on Tullock Creek near Hardin and Bighorn (see the Water Quality section). Figure 19 shows typical monthly mean discharge and a graph of the average monthly mean discharge in cubic feet per second for the Bighorn River at Bighorn, Montana, since flow regulation by Yellowtail Reservoir. This data was obtained from the U. S. Geological Survey's flow gaging station located approximately 0.75 miles upstream from the mouth of the Bighorn River. Both June and July are months of high monthly mean flow for the Bighorn River at this station. The high flows in June and July may be representative of the influence on flow of the Little Bighorn River. The relatively high average monthly mean flows for March are most likely attributable to the extensive prairie drainage above this station. Since November 1965 when the flow of the Bighorn River became regulated by Yellowtail Reservoir, the maximum recorded flow at Bighorn has been 25,200 cfs and the minimum has been 200 cfs. There is extensive irrigation all along the Bighorn River which affects flow values. Figure 4 is a schematic diagram of surface waters in the Bighorn River sub-basin.

ROSEBUD CREEK SUB-BASIN

The drainage area of Rosebud Creek is about 1270 square miles. Rosebud Creek has its source in the Wolf and Rosebud Mountains. In its upper drainage this stream is fed by many springs and several small creeks. The Wolf and Rosebud Mountains have a low altitude and low relief. They are forest covered but generally do not accumulate a significant snow pack. The lower drainage is the larger portion of the sub-basin and flow characteristics of Rosebud Creek are those of a prairie drainage rather than that of a combined mountainous and prairie drainage. There are no active U. S.

Geological Survey flow gaging stations in this sub-basin. Figure 20 shows monthly mean discharges and a graph of average monthly mean discharges in cubic feet per second for Rosebud Creek near Forsyth. The data for Figure 20 was obtained from a U. S. Geological Survey flow gaging station which was located about five miles upstream from the mouth of Rosebud Creek. As the graph indicates, high monthly mean flows generally occur in March, which is consistent with a prairie drainage. The maximum discharge observed was 596 cfs and periods of no flow were recorded (Ref. 26). There are some diversions for irrigation on Rosebud Creek. There are no major tributaries to Rosebud Creek in the sub-basin. Flows were measured when water quality samples were collected by the Water Quality Bureau. Figure 4 is a schematic diagram of the surface waters in the Rosebud Creek sub-basin.

TONGUE RIVER SUB-BASIN

This sub-basin is 3640 square miles in area. The Tongue River originates in the eastern portion of the Bighorn Mountains in Wyoming (schematic in Fig. 29). It flows into Montana near Decker, Montana (Plate I). Figure 21 shows typical monthly mean discharges and a graph of an average monthly mean discharge for the Tongue River at the Montana/Wyoming border. There are many small reservoirs on the Tongue River drainage in Wyoming which tend to regulate the flow at this station. The maximum flow recorded has been 7480 cfs and the minimum has been 3.9 cfs (Ref. 27). The graph of Figure 21 shows June to be the high monthly mean flow month and November through January to be the low monthly mean flow months. The Tongue River flows about five miles in Montana before emptying into the Tongue River Irrigation Reservoir. In the reach of the Tongue River from the state line to the reservoir there are no major tributary creeks. There is some peak discharge data available from the U. S. Geological Survey on Spring Creek which enters the Tongue River Reservoir near Decker. Spring Creek has a relatively small drainage and is intermittent. Flow data was taken on Deer Creek, a tributary to the Tongue River Reservoir when water quality samples were collected by the Water Quality Bureau, Montana State Department of Health and Environmental Sciences (see Water Quality). Deer Creek has a substantial drainage but is an intermittent stream. The U. S. Geological Survey has some peak discharge data on Leaf Rock Creek which empties into the lower end of the Tongue River Reservoir. This creek has a relatively small drainage area and is intermittent. Figure 22 shows typical monthly mean discharges and a graph of an average monthly mean discharge for the Tongue River at the Tongue River Dam.

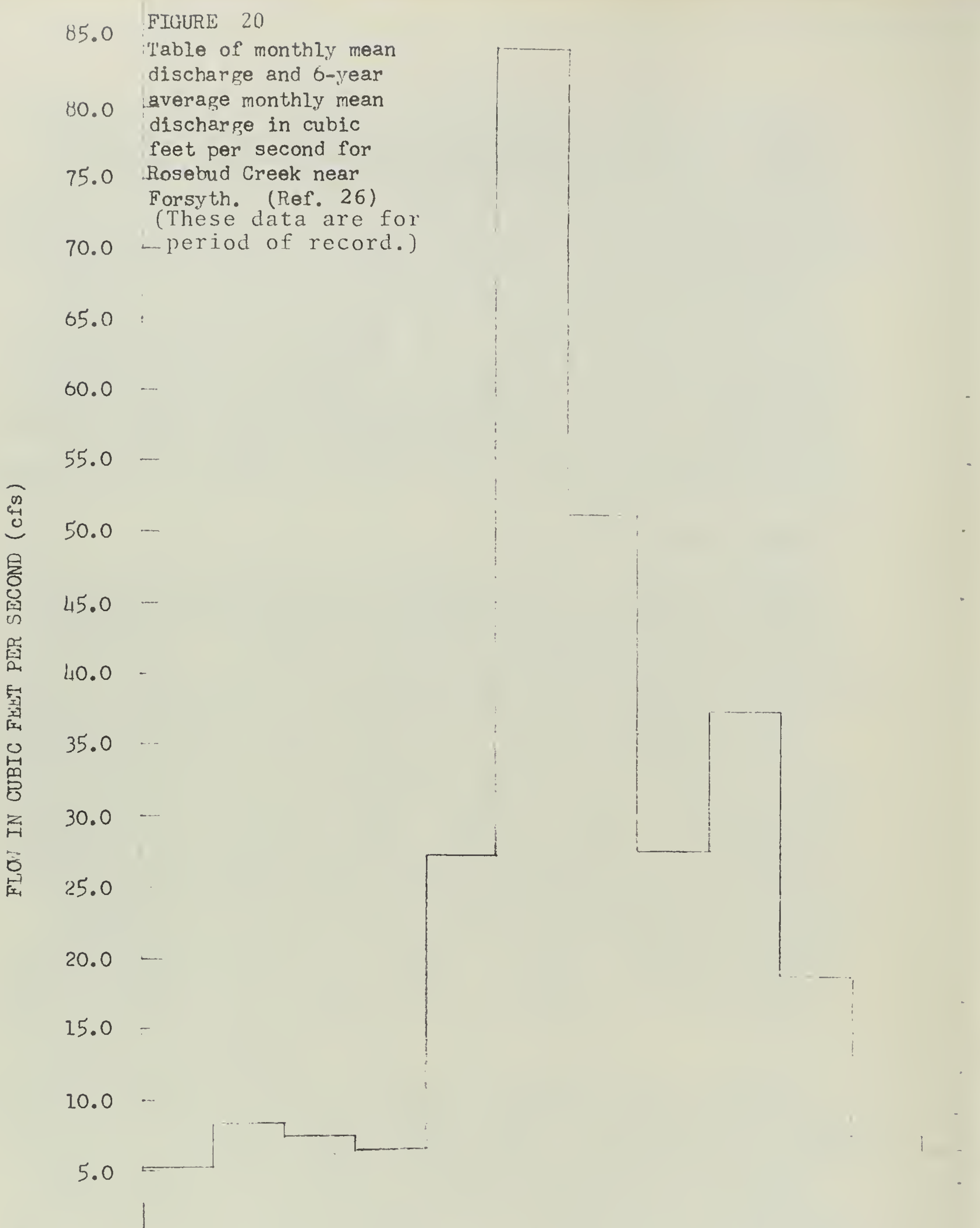


FIGURE 20
Table of monthly mean discharge and 6-year average monthly mean discharge in cubic feet per second for Rosebud Creek near Forsyth. (Ref. 26)
(These data are for period of record.)

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1948	4.89	8.82	10.8	9.1	26.9	77.4	88.6	50.3	75.4	81.3	15.3	5.01
1949	8.85	12.9	11.1	12.0	46.9	173	47.5	24.2	18.8	5.25	1.76	0.57
1950	7.28	13.2	8.6	3.4	24.9	100	46.4	39.8	41.5	10.7	3.41	3.96
1951	1.60	7.58	7.2	5.3	23.5	66.2	49.7	8.54	24.5	2.55	15.2	27.9
1952	5.16	5.43	5.7	8.0	36.0	78.5	79.5	8.72	6.85	2.05	0.17	0.003
1953	3.06	2.47	0.24	1.05	4.95	10.7	2.53	35.5	57.1	11.3	7.81	1.12
Average	5.14	8.40	7.27	6.48	27.2	84.3	52.4	27.8	37.4	18.9	7.28	6.43

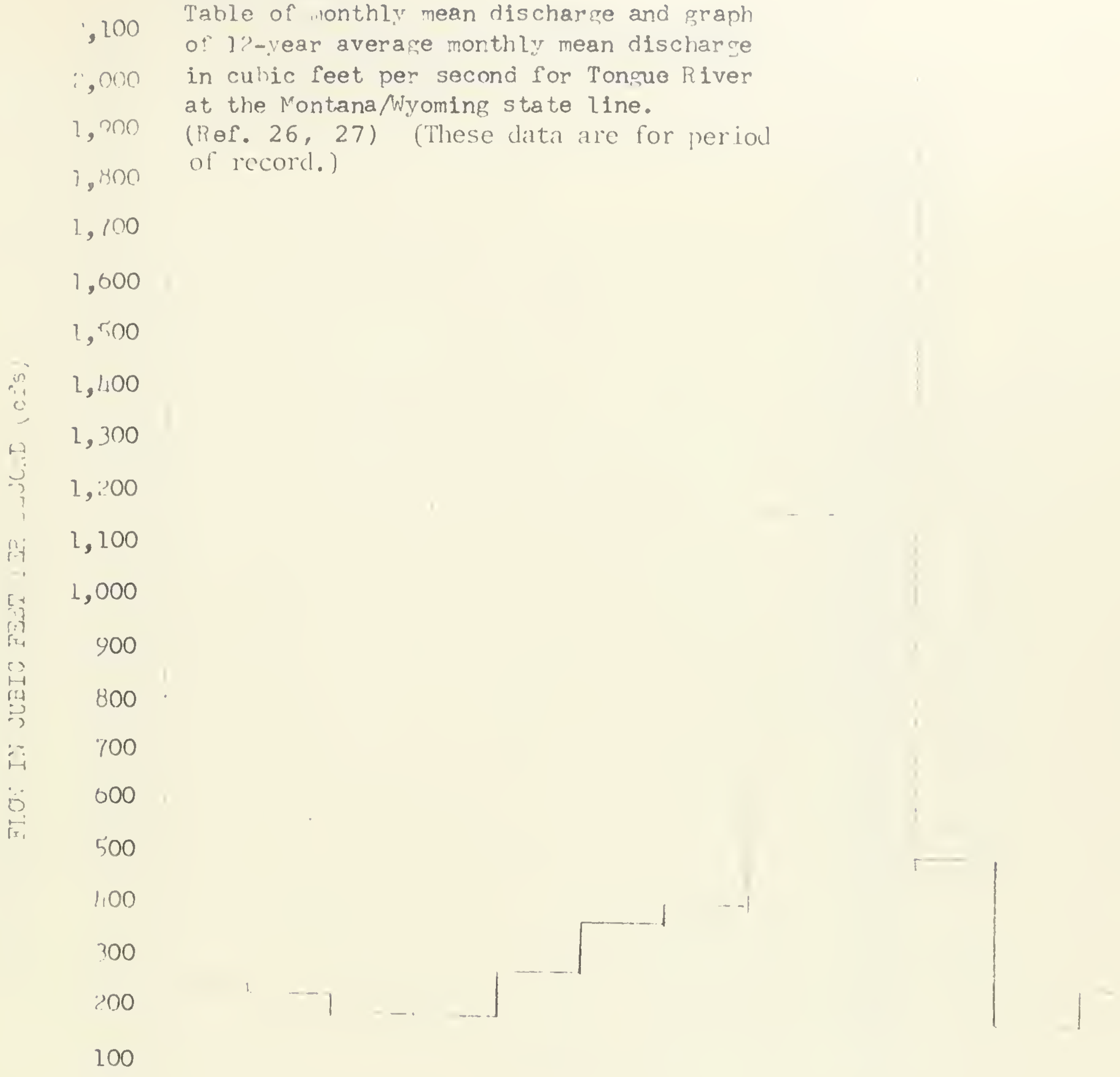
The flow at this station is regulated by the reservoir. The graph shows the high monthly mean discharge month to be June with November through February being months of low flow. This graph is approximately the same as the one for the Tongue River at the state line with the exception of the months of May and August. Both of these months show larger values of discharge from the reservoir. Thus, the reservoir has extended irrigation by making more water available during these months. The maximum discharge recorded for this station has been 7340 cfs and the minimum flow has been 0.0 cfs due to closure of the gates at the dam (Ref. 27). Between the flow gaging station at the dam and the station near Ashland on the Tongue River two major creeks enter the Tongue River, Hanging Woman Creek and Otter Creek. The U. S. Geological Survey has just initiated stream flow stations on these creeks. The data is not yet published. The station on Hanging Woman Creek is about one-half mile upstream from its mouth near Birney and coincides with a water quality sampling site of the Water Quality Bureau of the Montana State Department of Health and Environmental Sciences. Flow data was taken at this site when samples were collected (see Water Quality). The Hanging Woman Creek drainage begins near the Montana/Wyoming border and runs generally north meeting the Tongue River near Birney (Plate I). The creek is intermittent for most of its drainage. The Otter Creek drainage also begins near the Montana/Wyoming border, and runs generally north meeting the Tongue River near Ashland. The U. S. Geological Survey flow gaging station on Otter Creek is located near the mouth at Ashland (Plate I and Figure 1). This station, also, is a water quality sampling station of the Water Quality Bureau. Flow data was obtained at this site when samples were collected (see Water Quality). There is some seasonal flow data available for Stebbins Creek and Walking Horse Creek which are intermittent tributaries to the Tongue River in this reach. The U. S. Geological Survey maintains a flow gaging station on the Tongue River near Ashland. This station is located about 14 miles below the confluence of Otter Creek. Figure 23 shows typical monthly mean discharges and a graph of a six-year average monthly mean discharge for the Tongue River near Ashland (based on USGS data). Average monthly mean discharge for the months of April and August are higher than might be expected without regulation provided by the reservoir. The higher average monthly mean discharge for March can probably be attributed to runoff from tributaries between the reservoir and the gaging station near Ashland; especially Hanging Woman and Otter Creeks. Since these creeks have prairie drainages, they would be expected to have high discharges during this period. The recorded maximum flow for the Tongue River near Ashland has been 5740 cfs and the minimum 50 cfs. There is substantial diversions for irrigation above this station (Ref. 27). There are many intermittent streams having small drainage areas that are tributary to the Tongue River below this station. In this final reach of the Tongue River, there is only one major tributary, Pumpkin Creek. Pumpkin Creek has a relatively large drainage, which parallels the Tongue River. The creek enters the Tongue River about ten miles above the Tongue River's confluence with the Yellowstone River near Miles City. The drainage of Pumpkin Creek is one of a prairie nature (Plate I). The U. S. Geological Survey maintains a flow gaging station on Pumpkin Creek about two miles above its mouth. As yet, there is no published flow data for this station. However, this site was also used by the Water Quality Bureau for water quality sampling and flows were determined each time samples were collected (see Water Quality). It is likely that this creek is either intermittent or ephemeral. Figure 24 shows typical monthly mean discharge and a graph of average monthly mean discharge for the Tongue River near Miles City. The U. S. Geological Survey station from which this data was compiled is located approximately eight miles upstream from the mouth of the Tongue River. Flows at this station are similar to those near Ashland with the exception of a lower average monthly mean flow in August. This is probably attributable to irrigation diversions. The increased flow in the Tongue River in March near Ashland (Fig. 23) probably is due to inflow from a number of prairie-type tributaries. The maximum flow recorded at this station has been 13,300 cfs and the minimum has been 0 cfs (Ref. 27).

YELLOWSTONE RIVER MAINSTEM - BIGHORN RIVER TO TONGUE RIVER SUB-BASIN

This sub-basin contains approximately 4060 square miles. This reach of the Yellowstone is not truly a free flowing stream. Regulation of the Bighorn River since 1965 significantly affects the flow of the Yellowstone in this area except during the summer high flow period. Examination of the tables of Figures 8 and 19 shows that the average monthly mean discharge for the months of October, November, December, January, February, March, and April are about the same for both the Yellowstone at Billings and the Bighorn at Bighorn. Thus, during this period of the year, the Bighorn is providing about one-half the flow of the Yellowstone below their confluence. In March the average monthly mean discharge in the Bighorn is substantially larger than in the Yellowstone. As mentioned in the

FIGURE 21

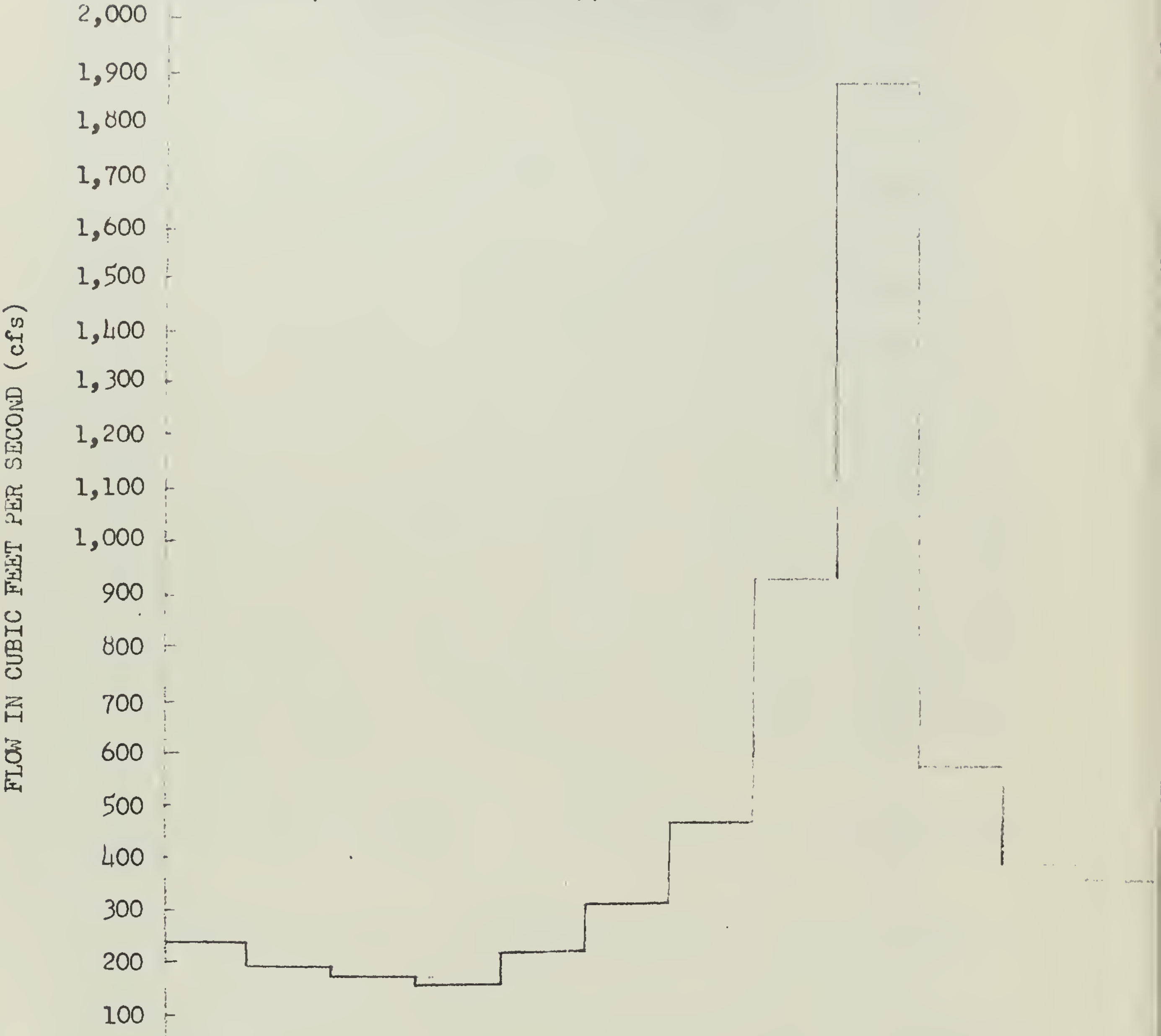
Table of monthly mean discharge and graph of 12-year average monthly mean discharge in cubic feet per second for Tongue River at the Montana/Wyoming state line. (Ref. 26, 27) (These data are for period of record.)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1961	116	150	145	133	157	129	124	500	594	87.5	16.5	98.3
1962	270	223	191	190	298	263	525	1009	1651	460	187	241
1963	252	208	140	171	324	204	366	1620	2886	362	83.5	115
1964	130	195	150	153	157	181	341	1291	2817	814	152	228
1965	227	225	227	230	276	368	556	1099	2189	570	192	322
1966	306	221	151	108	156	242	265	762	342	90.2	55.9	74.2
1967	174	182	145	169	198	230	258	1184	3007	860	186	274
1968	295	261	193	254	402	391	283	884	3165	651	475	615
1969	403	317	250	207	179	698	576	1275	1024	624	110	102
1970	247	258	235	176	250	386	528	1964	2931	599	161	239
1971	275	256	242	245	672	466	582	1205	1949	340	101	182
1972	310	291	211	210	280	855	382	1048	1346	393	249	269
Average	250	232	190	187	279	368	399	1153	1992	486	164	230

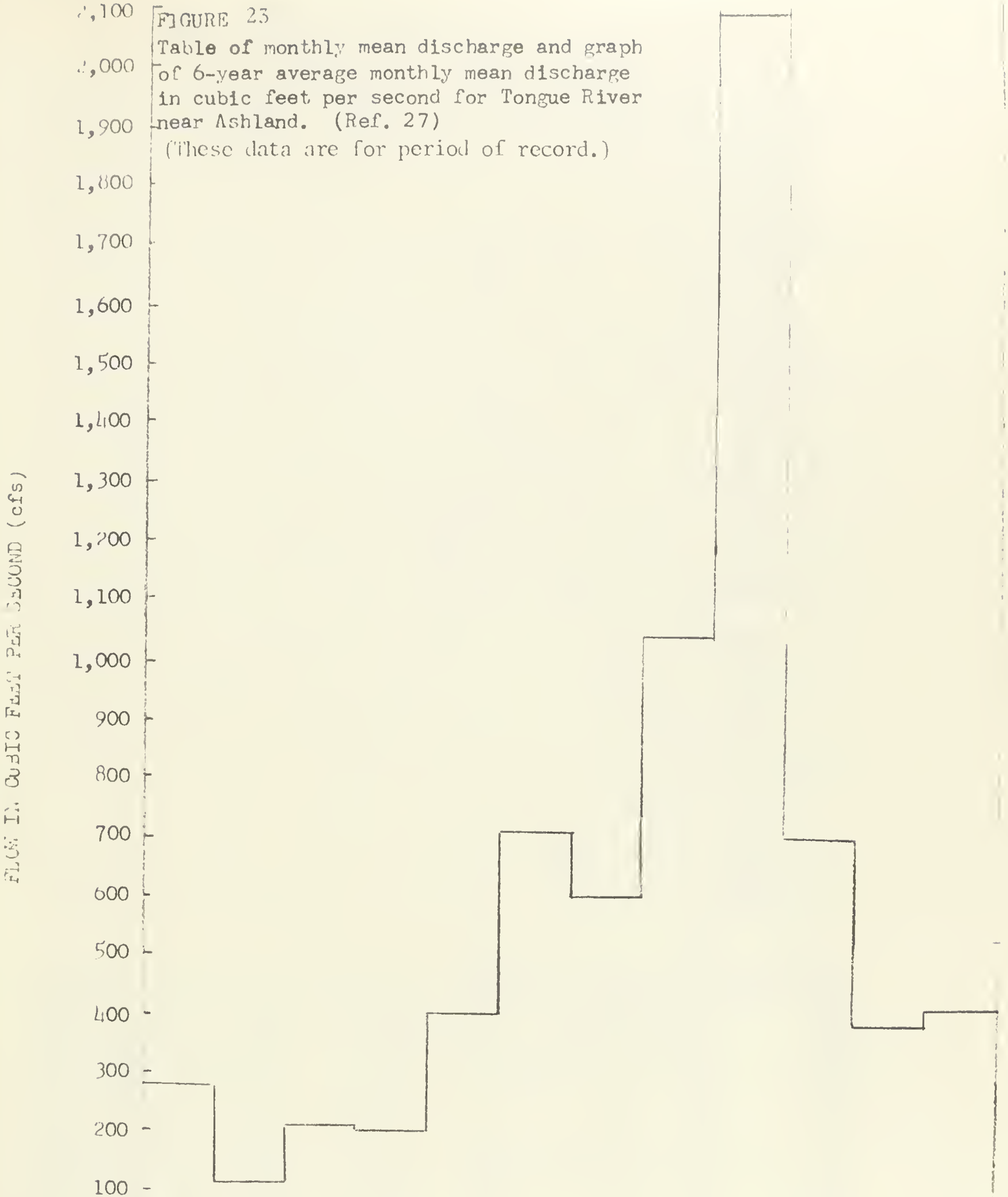
FIGURE 22

Table of monthly mean discharge and graph of 12-year average monthly mean discharge in cubic feet per second for Tongue River at Tongue River Dam. (Ref. 26, 27)
(Data for period illustrate typical flows.)



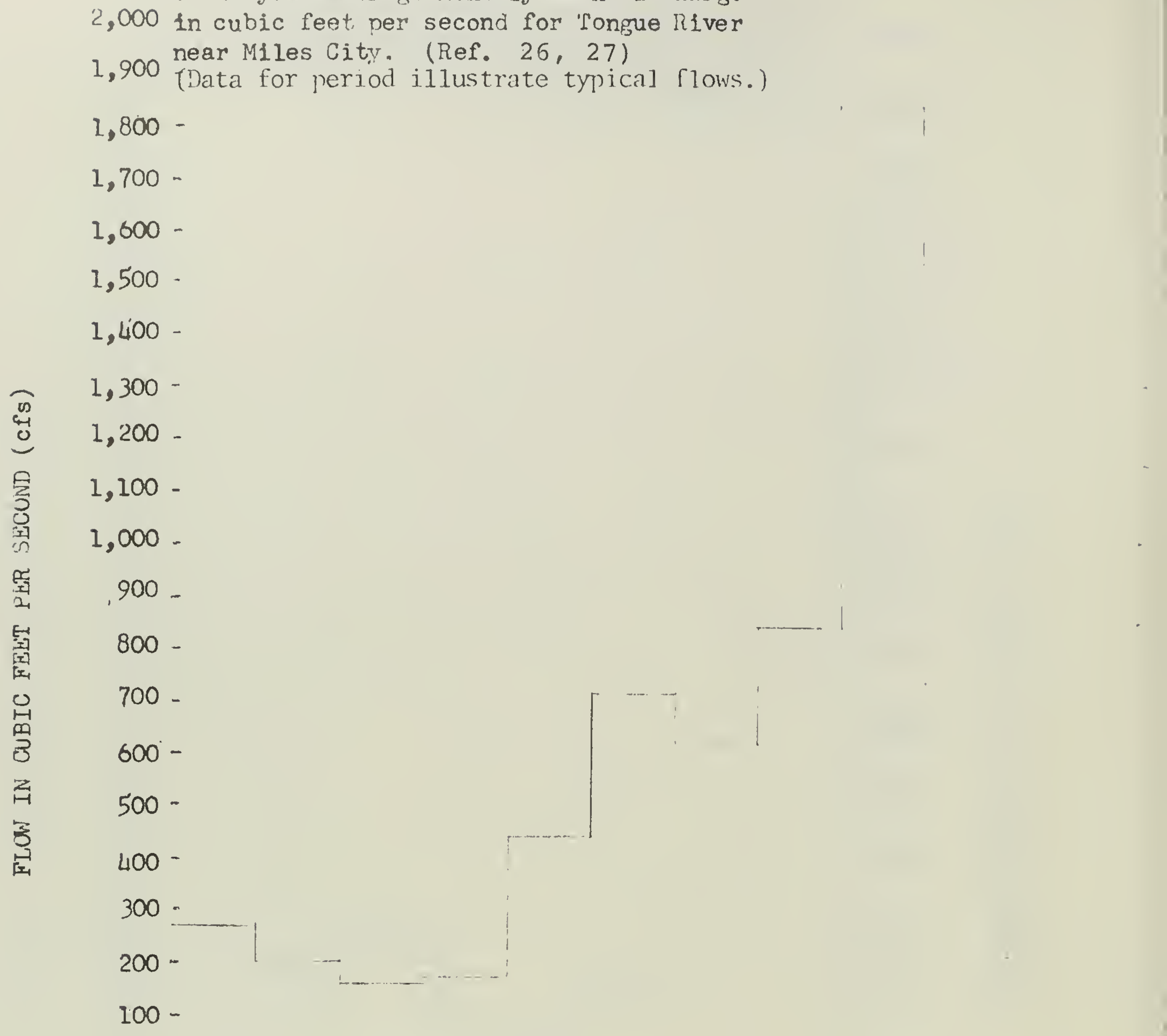
Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1961	111	96.3	86.5	79.9	56.9	22.7	115	195	390	307	240	138
1962	103	93.9	149	150	279	403	631	986	1939	367	395	367
1963	290	209	191	134	217	367	203	1764	2773	323	316	197
1964	77.1	60.4	90.8	174	183	188	332	1329	2567	946	386	458
1965	298	258	146	219	291	245	958	1040	1633	551	412	469
1966	509	270	144	111	111	89.4	171	493	410	383	336	198
1967	78.9	69.8	108	124	125	140	308	905	3258	924	444	334
1968	234	322	197	162	159	429	450	746	2942	707	534	687
1969	493	244	251	206	209	347	583	1250	922	860	384	371
1970	154	118	294	236	224	293	568	1891	2837	592	396	343
1971	288	251	170	173	592	676	588	1303	1639	387	335	269
1972	179	262	223	195	194	558	706	978	1236	484	415	398
Average	235	188	171	164	220	313	468	928	1879	569	383	352

FIGURE 23
Table of monthly mean discharge and graph of 6-year average monthly mean discharge in cubic feet per second for Tongue River near Ashland. (Ref. 27)
(These data are for period of record.)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1967	124	92.8	102	148	190	232	315	736	3084	1110	397	344
1968	251	302	256	235	334	553	475	671	2754	749	539	757
1969	560	303	241	195	212	854	692	1112	923	901	368	373
1970	231	144	240	222	275	357	599	1050	2826	638	365	335
1971	307	267	178	184	1211	1342	726	1195	1695	391	297	300
1972	235	301	248	237	266	927	826	884	1296	500	386	398
Average	285	117	211	204	415	709	606	1041	2096	715	392	418

FIGURE 24
Table of monthly mean discharge and graph of 12-year average monthly mean discharge in cubic feet per second for Tongue River near Miles City. (Ref. 26, 27)
(Data for period illustrate typical flows.)



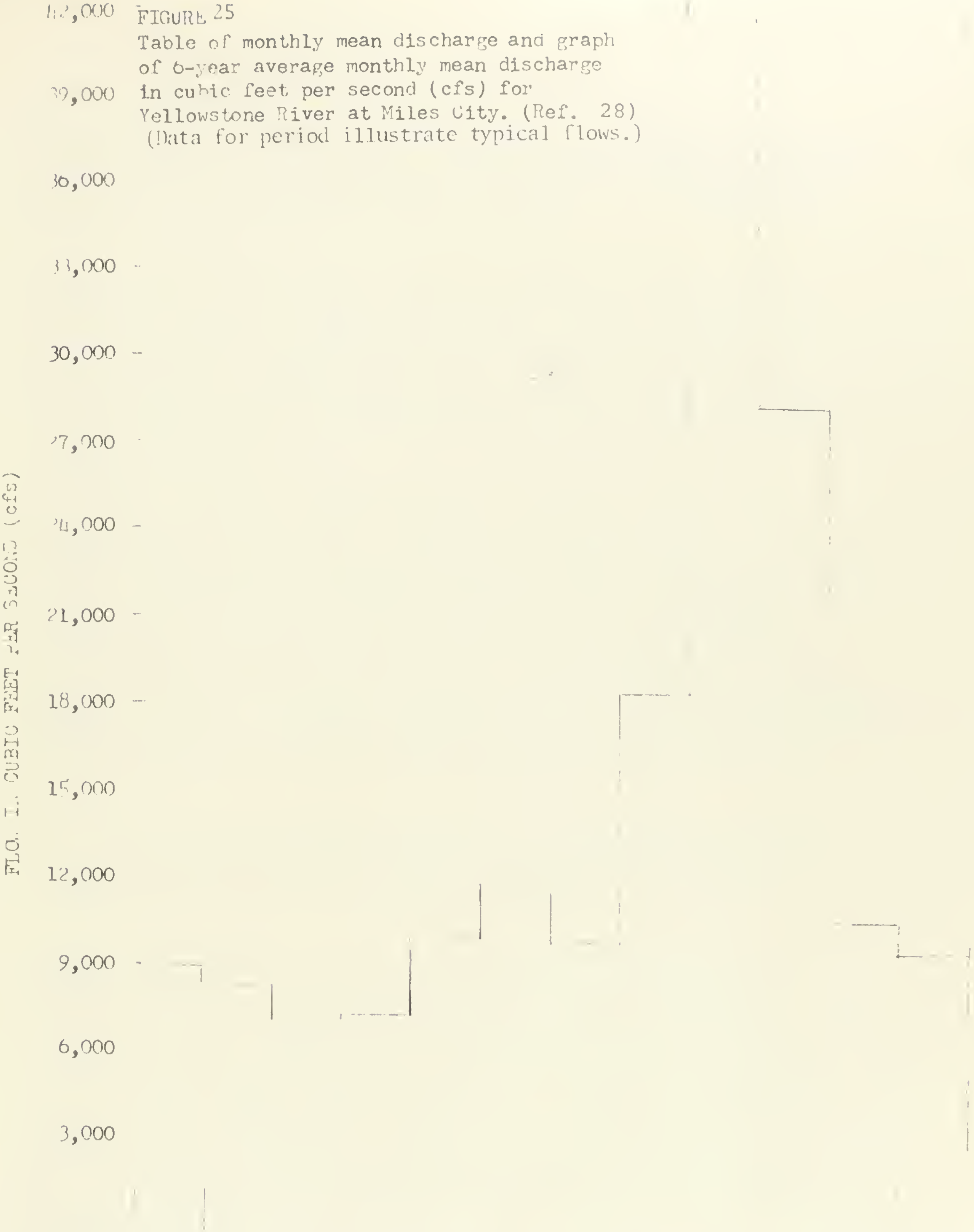
Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT.
1961	10.3	92.8	70.3	78.6	102	79.8	12.5	29.2	99.6	34.0	7.24	77.1
1962	79.8	79.2	133	136	273	567	617	805	2176	410	131	223
1963	237	206	172	133	690	460	230	1410	2966	371	126	194
1964	25.5	76.8	69.7	142	180	195	302	847	2496	976	291	297
1965	208	192	168	221	479	604	1693	992	1361	778	215	332
1966	573	328	186	142	140	252	138	203	228	164	104	114
1967	34.9	94.8	103.	157	235	312	342	632	3493	1094	192	318
1968	231	327	236	284	531	776	448	537	2730	663	577	599
1969	536	315	200	204	214	1512	1046	1107	811	909	163	187
1970	202	142	223	215	263	405	599	1536	2689	504	138	209
1971	267	283	208	198	1794	1783	979	1175	1689	234	103	225
1972	694	359	201	169	319	1547	950	780	1380	351	240	237
Average	258	208	164	173	435	708	613	838	1843	541	190	253

sub-section "Bighorn River Sub-basin," those streams with considerable prairie drainage probably produce this flow condition. There is some sporadic flow data available from the U. S. Geological Survey on the Yellowstone at Myers but this is prior to the regulation of the Bighorn River. The only active U. S. Geological Survey flow gaging station on the Yellowstone in this reach is at Miles City below the confluence of the Tongue River. Between the confluence of the Bighorn and Tongue Rivers, there are five major streams entering the Yellowstone River; Sarpy Creek, Greater Porcupine Creek, Little Porcupine Creek, Armells Creek, and Rosebud Creek. Sarpy Creek originates in the Little Wolf Mountains which are located about 50 miles south of the Yellowstone River (Plate I). These mountains are basically hills of moderate to low relief. They support some forest cover but do not accumulate any snow pack. The creek runs northward meeting the Yellowstone near Hysham. The U. S. Geological Survey has recently established a stream flow gaging station about four miles upstream from the mouth of Sarpy Creek but as yet no data has been published. This site was also a water quality sampling site for the Water Quality Bureau. Flows were obtained each time water samples were collected from this site (see Water Quality). Sarpy Creek has basically a prairie drainage; thus high flows are expected to occur in late winter or early spring. Great Porcupine Creek drains a large desolate area north of the Yellowstone. It is an intermittent stream. Little Porcupine Creek, also, has a large drainage area north of the Yellowstone (Plate I). It is possible that this creek is ephemeral. There are quite a large number of stock watering reservoirs on these two creeks. Flows in these streams were obtained each time water quality samples were collected by the Water Quality Bureau (see Water Quality). Armells Creek begins in the Little Wolf Mountains. Its upper drainage is split into the East Fork and West Fork of Armells Creek. The stream flows generally north meeting the Yellowstone near Forsyth (Plate I). The U. S. Geological Survey has just established a stream gaging station on Armells Creek just a few miles upstream from the mouth. Samples were collected by the Water Quality Bureau at a number of sites along Armells Creek and stream flow was measured each time samples were collected (see Water Quality).

Rosebud Creek flows into the Yellowstone near Rosebud, Montana. Rosebud Creek has its highest average monthly mean discharge during March (Fig. 20). This is the period in which it would have its greatest contribution to the flow of the Yellowstone in this reach but it generally amounts to less than one percent of the Yellowstone. There are a number of intermittent streams of relatively small drainage areas which discharge to the Yellowstone in this reach. Individually, these streams between the confluence of the Bighorn and Tongue Rivers, have insignificant flows when compared to that of the Yellowstone, but collectively it is possible that they may at times influence the total flow of the Yellowstone. Since these streams have prairie drainages their effect on the flow of the Yellowstone would possibly be most significant during late winter and early spring.

Figure 25 shows the monthly mean discharge and an average monthly mean discharge in cfs for the Yellowstone at Miles City since regulation of the Bighorn by Yellowtail Reservoir. Comparing this with Figure 24 which shows similar data for the Tongue River near Miles City, they have about the same basic monthly profile with the exception of August. The flow from the Tongue is generally less than six percent of the flow of the Yellowstone at Miles City with the Tongue's largest contribution occurring in March. Comparison of Figures 8 and 25 shows the high average monthly mean discharges for the Yellowstone at Miles City in March to be absent for the Yellowstone River at Billings. Both the Bighorn and Tongue Rivers add significantly to the flow of the Yellowstone downstream from Billings during this period. Adding their flows to the flow of the Yellowstone at Billings and comparing this to the flow of the Yellowstone at Miles City, there is an unaccounted for increase in flow at Miles City. This is most likely attributable to combined flows of tributary streams and many small streams which have their high flow during this period. Maximum flow recorded for the Yellowstone at Miles City since November 1965 has been 69,600 and the minimum has been 2,510. Both of these occurred in the same water year as the recorded maximum and minimum for the Bighorn since regulation by Yellowtail (water year 1967).

FIGURE 25
Table of monthly mean discharge and graph of 6-year average monthly mean discharge in cubic feet per second (cfs) for Yellowstone River at Miles City. (Ref. 28) (Data for period illustrate typical flows.)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1967	5417	5507	5329	5439	6046	6939	5959	13570	52350	46310	10880	8023
1968	8672	8561	7893	8897	10720	10380	8450	12310	46790	23510	12680	11940
1969	10090	9188	6673	7000	7564	13220	10970	19830	27430	23390	8095	6599
1970	8089	7470	7242	7084	8586	6874	6060	22380	45660	26720	7820	8050
1971	8455	8002	6979	7784	16160	13080	13170	21670	45850	27850	10560	10100
1972	12970	10080	7410	6419	8879	17560	12590	18550	41410	19390	11520	10090
Average	8949	8135	6921	7104	9659	11340	9533	18050	43250	27860	10260	9134

VIII. WATER QUALITY

There is little available water quality data on streams other than the Yellowstone, Bighorn, and Tongue Rivers in the Middle Yellowstone Basin. Table 8 gives a summary of the type of water quality data available for the streams in this basin.

Concentration of dissolved constituents decreases with an increase in stream flow. This is primarily due to the dilution effect of water from runoff and snow melt. The decrease in concentration, however, is not as much as the increase in stream flow (i.e., an increase in stream flow by a factor of 10 may decrease the concentration of constituents only by a factor of 2). Thus, the net result of increased stream flow is an increase in total loads of dissolved material.

Suspended sediment concentration increases rapidly with an increase in stream flow. This is possibly due to a combination of factors. Increase in flow is due not only to larger stream cross sections but velocity of the water also increases enabling a stream to erode at its banks and bottom. During high flows, more loosely held sediment is suspended and moved whereas during the recession period of high flow most of this loosely held sediment has been removed. Thus, for a given stream a period of flow increase causes a larger sediment concentration. Increase in sediment concentration plus increased flow results in greatly increased sediment loads in the streams during a high flow period.

Since concentrations of dissolved and suspended material in a stream are dependent upon the stream flow, averages of concentrations derived from varied flows can be misleading unless they are flow adjusted.

Table 9 shows mean values of common ions during high and low stream flow conditions for several streams in the Middle Yellowstone Basin with several years of record. For stations on the Bighorn River, only water quality data collected after regulation by Yellowtail Reservoir was assessed. The Yellowstone River has the lowest concentrations of the common ions and shows a sizable variation in concentration from high to low flow. The Bighorn River shows little variation in concentration between high and low flow periods due to regulation of flow by Yellowtail Dam. Concentrations of common ions particularly sulfate in the Bighorn are considerably higher than those for the Yellowstone River.

Table 8

Summary of Water Quality Sampling Stations and Data from the Middle Yellowstone Basin

SAMPLING STATION DESIGNATION	SAMPLING STATION LOCATION*	SAMPLING AGENCY	DATA TYPE			PERIOD OF COLLECTION
			BIO	CHEM	PHYS	
Sage Creek @ Warren	09S 25E 10CCC	WQB	X	X	X	11/73-7/74
Crooked Creek nr Warren	09S 27E 34AAB	WQB	X	X	X	11/73-7/74
Hay Creek nr Pryor	04S 27E 21AA	WQB	X	X	X	11/73-7/74
E Fork Pryor Creek nr Pryor	05S 27E 13ABB	WQB	X	X	X	11/73-7/74
Pryor Creek nr Huntley	02N 27E 25CDD	WQB	X	X	X	7/73-7/74
Pryor Creek above Pryor	06S 26E 06CA	USGS	X	X	X	4/21-current
Pryor Creek @ Pryor	05S 26E 05ABA	USGS			X	6/21-current
Yellowstone R & Huntley	02N 27E 24AC	USGS		X		7/72-9/72
Arrow Creek nr Ballantine	02N 29E 08BDD	WQB	X	X	X	10/73-7/74
Fly Creek @ Pompeys Pillar	03N 30E 23BD	WQB	X	X	X	10/73-7/74
Fly Creek @ Pompeys Pillar	03N 30E 23BD	USGS		X	X	10/68-current
Bighorn Lake nr St. Xavier	06S 31E 18CD	USGS			X	11/65-current
Bighorn River nr St. Xavier	06S 31E 16BA	USGS		X	X	10/34-current
Soap Creek nr St. Xavier	06S 32E 10A	USGS			X	9/11-9/72
Soap Creek nr St. Xavier	05S 32E 29ABA	WQB	X	X	X	Intermittent 10/73-7/74
Rotten Grass Creek @ St. Xavier		WQB	X	X	X	10/73-7/74
Rotten Grass Creek nr St. Xavier	05S 33E 07A	U.S.G.S.			X	9/11-9/72
Beauvais Creek nr St. Xavier	04S 30 E 15BC	U.S.G.S.		X	X	Intermittent 7/67-current
Bighorn River nr Hardin	01S 33E 24 AD	U.S.G.S.		X		1/51-9/72
Tullock Creek nr Big Horn		WQB	X	X	X	Intermittent 10/73-7/74
Bighorn R @ Big Horn	05N 34E 33AA	U.S.G.S.		X	X	5/45-current
Bighorn R @ Big Horn	05N 34E 33AA	WQB	X	X	X	7/73-7/74
Little Bighorn nr Hardin	01S 34E 19AA	U.S.G.S.		X	X	6/53-current
Little Bighorn nr Hardin		WQB	X	X	X	7/73-7/74
Lodge Grass Creek @ Lodge Grass		WQB	X	X	X	7/73-7/74
Lodge Grass Creek nr Lodge Grass	08S 34E 19BB	U.S.G.S.			X	3/39-current
Owl Creek nr Lodge Grass	06S 36E 30ABB	WQB	X	X	X	7/73-7/74

(Continued)

TABLE 8

SAMPLING STATION DESIGNATION	SAMPLING STATION LOCATION	SAMPLING AGENCY	DATA TYPE BIO	DATA TYPE CHEM	DATA TYPE PHYS	PERIOD OF COLLECTION
Little Bighorn R nr Wyola	07S 35E 35 BC	U.S.G.S.		X	X	3/39-current Intermittent
Little Birhorn R nr Wyola	07S 35E 35 ACC	WQB	X	X	X	7/73-7/74
Pass Creek nr Wyola	08S 35E 22 ACD	WQB	X	X	X	7/73-7/74
Little Bighorn R @ state line	09S 33E 36 CB	U.S.G.S.			X	3/39-current
Tullock Creek nr Hardin	01N 35E 36 DD	WQB				11/73-7/74
Yellowstone R nr Myers	06N 35E 21 DC	WQB	X	X	X	11/73-7/74
Yellowstone R nr Myers		U.S.G.S.		X	X	
Sarpy Creek nr Hysham	06N 37E 30 DDA	U.S.G.S.			X	9/73-current
Sarpy Creek nr Hysham	06N 37E 18 AB	WQB	X	X	X	7/73-7/74
Armells Creek nr Forsyth	06N 39E 23 AC	WQB	X	X	X	7/73-7/74
Armells Creek @ Hiway 312	05N 39E 36 BB	WQB	X	X	X	11/73-7/74
E Fork Armells Creek @ Hiway 312	04N 40E 22 CA	WQB	X	X	X	11/73-7/74
W Fork Armells Creek nr Hiway 312	04N 40E 16 AB	WQB	X	X	X	11/73-7/74
E Fork Armells Creek nr Colstrip	01N 41E 03 BB	WQB	X	X	X	11/73-7/74
Yellowstone R @ Forsyth	06N 40E 22 AA	WQB	X	X	X	7/73-7/74
Yellowstone R @ Forsyth		U.S.G.S.		X	X	
Great Porcupine Creek nr Forsyth	07N 38E 13 AA	WQB	X	X	X	7/73-7/74
Little Porcupine Creek nr Forsyth	06N 41E 02 ACD	WQB	X	X	X	7/73-7/74
Reservation Creek @ Hiway 94	06N 38E 34 CB	WQB	X	X	X	11/73-7/74
Rosebud Creek @ Rosebud	06N 42E 16 DCC	WQB	X	X	X	7/73-7/74
Rosebud Creek @ Busby	04N 39E 06 ABA	WQB	X	X	X	7/73-7/74
Rosebud Creek @ Kirby	06S 39E 29 BA	WQB	X	X	X	7/73-7/74
Lame Deer Creek @ Lame Deer	02S 41E 28 DB	WQB	X	X	X	7/73-7/74
Tongue River @ state line	09S 40E 33 BA	U.S.G.S.		X	X	8/60-current
Tongue River below Dam	08S 40E 13 A	U.S.G.S.			X	5/39-current
Tongue River @ Birney Village	05S 43E 08 DD	WQB	X	X	X	7/73-7/74
Tongue River nr Birney		U.S.G.S.		X	X	
Hanging Woman Creek nr Birney		U.S.G.S.			X	
Hanging Woman Creek nr Birney	06S 43E 19 DDA	WQB	X	X	X	7/73-7/74
Hanging Woman Creek nr Otter	08S 43E 17 DD	WQB	X	X	X	11/73-7/74
Tongue River @ Ashland	03S 44E 10 BD	WQB	X	X	X	7/73-7/74
Otter Creek @ Ashland	03S 44E 11 ADC	WQB	X	X	X	7/73-7/74
Tongue River nr Ashland	01S 44E 02 ACC	U.S.G.S.			X	9/66-current
Otter Creek nr Ashland		U.S.G.S.			X	9/73-current
Otter Creek nr Otter	07S 45E 13 DC	WQB	X	X	X	11/

(Continued)

TABLE 8

SAMPLING STATION DESIGNATION	SAMPLING STATION LOCATION	SAMPLING AGENCY	DATA TYPE BIO	DATA TYPE CHEM	DATA TYPE PHYS	PERIOD OF COLLECTION
Tongue River nr Ashland	03S 44E 03 BA	WQB	X	X	X	11/73-7/74
Tongue River nr Garland	03S 46E 30 CC	WQB	X	X	X	11/73-7/74
Tongue River @ Brandenberg		U.S.G.S.		X	X	
Pumpkin Creek nr Miles City	06N 48E 29 ACC	WQB	X	X	X	7/73-7/74
Pumpkin Creek nr Volborg	01N 48E 13 AC	WQB	X	X	X	11/73-7/74
Little Pumpkin Creek nr Volborg	01S 48E 11 BC	WQB	X	X	X	11/73-7/74
Pumpkin Creek @ Hiway 212	03S 48E 29 DD	WQB	X	X	X	11/73-7/74
Tongue River @ Miles City	07N 47E 04 DD	WQB	X	X	X	7/73-7/74
Tongue River @ Miles City	07N 47E 23 DD	U.S.G.S.		X	X	4/38-current Intermittent
Yellowstone River nr Rosebud	06N 42E 15 BC	WQB	X	X	X	11/73-7/74
Little Bighorn River @ state line	09S 33E 36 CB	WQB	X	X	X	11/73-7/74

* See Appendix A

The Tongue River is regulated but shows greater variation in concentrations from high to low flow than does the Bighorn River. There is possibly a couple of reasons for this difference: (1) the discharge from Yellowtail Reservoir comes from waters about 150 feet to 200 feet below the surface in contrast to the near surface withdrawal from the Tongue River Reservoir; and (2) Yellowtail Dam provides substantially more regulation than does the Tongue River Dam. The average concentrations of common ions are generally higher for the Tongue River than for the Yellowstone River at Miles City. The exception is chloride. A unique feature of the Tongue River is that on the average at low flow conditions the milliequivalence per liter of magnesium is larger than that of calcium.

There is a general increase in average concentrations of common ions for the Yellowstone River between Billings and Miles City (Table 9), particularly below the confluence of the Bighorn River. The Tongue River shows some slight increases in the concentrations of the ions from the state line to Miles City. As was pointed out in the Surface Water Resources section, the flow of the Tongue River at Miles City is generally most significant during June which corresponds to its lowest concentrations but highest loads.

Fly Creek and Beauvais Creek display typical values of smaller perennial streams in the basin. They are generally quite high in the concentrations of the common ions, especially calcium, sodium, bicarbonate, and sulfate. Beauvais Creek, also, has relatively high concentrations of strontium (Ref. 30, 53).

There has been quite an increase in water quality monitoring within the basin because of the increase in coal related development (see Related Investigations and Plans). Most of this work is being done by the U. S. Geological Survey, Water Resources Division (USGS).

Data tables for each of the sub-basins discussed in this section have data from both the USGS (Ref. 29, 30) and the Water Quality Bureau (WQB). Data up to 1973 was collected by the USGS and data dated as of 1973 and 1974 was collected by the WQB. The USGS data presented in these tables was selected in order to present water quality at high flows, low flows, and at warm weather low flows. This demonstrates the flow-related variations in concentrations of the various constituents. In addition, such a selection was necessary given the large amounts of data available from the USGS for certain sites. The WQB data is listed in the order of the dates that the samples were collected. Values for the

TABLE 9

MEAN HIGH FLOW AND LOW FLOW VALUES
OF COMMON PARAMETERS FOR SEVERAL WATER
QUALITY SITES IN THE MIDDLE YELLOWSTONE BASIN

Stream Station	CALCIUM High Flow Mg/1	CALCIUM High Flow Meg/1	CALCIUM Low Flow Mg/1	CALCIUM Low Flow Meg/1	MAGNESIUM High Flow Mg/1	MAGNESIUM High Flow Meg/1	MAGNESIUM Low Flow Mg/1	MAGNESIUM Low Flow Meg/1	SODIUM High Flow Mg/1	SODIUM High Flow Meg/1	SODIUM Low Flow Mg/1	SODIUM Low Flow Meg/1	BICARBONATE High Flow Mg/1	BICARBONATE High Flow Meg/1	BICARBONATE Low Flow Mg/1	BICARBONATE Low Flow Meg/1	SULFATE High Flow Mg/1	SULFATE High Flow Meg/1	SULFATE Low Flow Mg/1	SULFATE Low Flow Meg/1	CHLORIDE High Flow Mg/1	CHLORIDE High Flow Meg/1	CHLORIDE Low Flow Mg/1	CHLORIDE Low Flow Meg/1	SPECIFIC CONDUCTANCE High Flow micromhos/cm	SPECIFIC CONDUCTANCE Low Flow
Yellowstone River @ Billings	18	0.90	45	2.25	5.2	0.43	14	1.15	10	0.44	29	1.26	85	1.39	175	2.87	23	0.49	91	1.90	2.4	0.07	7.7	0.22	[illegible]	[illegible]
Fly Creek @ Pompeys Pillar	43	2.15	115	5.74	20	1.65	96	7.90	63	2.74	301	13.09	130	2.13	410	6.72	210	4.38	945	19.69	6.6	0.19	17	0.47	635	[illegible]
Beauvais Creek nr St. Xavier	[illegible]	[illegible]	225	12.72	[illegible]	1.65	54	4.44	64	2.78	47	2.04	163	2.67	221	3.62	279	5.81	761	15.85	3.0	0.09	2.9	0.08	992	[illegible]
[illegible] River @ Big Horn	73	3.64	73	3.64	25	2.06	29	2.39	74	3.22	83	3.61	205	3.36	211	3.46	264	5.50	300	6.25	10	0.28	11	0.31	[illegible]	952
[illegible] River @ State Line	34	1.70	73	3.64	17	1.40	60	4.94	14	0.61	53	2.30	129	2.12	289	4.74	72	1.50	295	6.17	2.6	0.07	5.5	0.15	320	381
Tongue River @ Miles City	41	2.05	73	3.64	24	1.97	49	4.03	32	1.39	73	3.17	181	2.97	315	5.16	120	2.50	268	5.59	3.2	0.09	4.4	0.12	569	[illegible]
[illegible] River @ Miles City	30.	1.50	64	3.19	9.1	0.75	23.	1.89	24.	1.04	65	2.83	112	1.84	201	3.30	70	1.46	216	4.50	4.4	0.12	11	0.31	[illegible]	[illegible]
[illegible] MEAN [illegible] FOR ABOVE [illegible]	45.7	2.28	95.4	4.97	17.2	1.42	46.2	3.82	40.0	1.75	93	4.04	143.6	2.35	296.3	4.27	148.3	3.09	410.9	9.21	4.6	0.13	6.5	0.24	574.6	[illegible]

heavy metals obtained by the WQB can all be designated as "total recoverable" (unfiltered and acidified).

SAGE CREEK SUB-BASIN

Streams in the Sage Creek sub-basin have been classified as B-D_1 by the Montana State Department of Health and Environmental Sciences (Appendix I). Sage Creek is the principal stream in the sub-basin. All others are tributaries to Sage Creek and have small drainage areas. There is a lack of water quality data for this sub-basin. The WQB established two sampling sites on Sage Creek; one at the base of the Pryor Mountains near the Old Bridger Camp and one in the lower drainage at the Montana/Wyoming border near Warren (Plate I, Figure 1). There is some water quality data available for the lower reaches of Sage Creek in Wyoming from USGS sampling stations near Deaver and at Lovell, Wyoming.

Concentrations of parameters for Sage Creek (Table 10) are higher for those sites in Wyoming. Stations in Wyoming are influenced by waters from the Shoshoni River. This could possibly be the reason for the discrepancy. In Montana, concentrations of the parameters in Table 10 increase slightly from the upper to the lower site. Sodium, sulfate, chloride, and total suspended sediment show the most significant increases. The sodium, bicarbonate, sulfate, chloride, iron, total suspended sediment, and calculated dissolved solids loads have been determined for the sample collected on Sage Creek near Warren on May 30, 1974. Those results are listed below:

Sodium (Na)	7.0 T/day
Bicarbonate (HCO_3)	35.0 T/day
Sulfate (SO_4)	29.0 T/day
Chloride (Cl)	1.5 T/day
Iron (Total recoverable) (Fe)	0.7 T/day
Total Suspended Sediment (TSS)	26.0 T/day
Calculated Dissolved Solids (CDS)	480.0 T/day

PRYOR CREEK SUB-BASIN

Streams in this sub-basin have been designated B-D_1 by the Water Quality Bureau (WQB) of the Montana State Department of Health and Environmental Sciences (Appendix I). Pryor Creek is the principal stream in this sub-basin. Two sampling sites were established by the WQB; an upper site on Pryor Creek at Pryor, Montana, and a lower site at Huntley, Montana. Minor streams sampled in this sub-basin by the WQB were the East Fork of Pryor Creek, Hay Creek, and the East

Table 10
Typical chemical analysis of surface waters in the Sage Creek sub-basin.

Sampling Site Designation	Sampling Site Location *	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25° C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness $CaCO_3$ (mg/l)	Bicarbonate HCO_3 (mg/l)	Carbonate CO_3 (mg/l)	Alkalinity $CaCO_3$ (mg/l)	Sulfate SO_4 (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO_3 (mg/l)	Phosphate PO_4 (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
<u>Sage Creek Mainstem</u>																																			
near Deaver		8/20/58	160		7.9	1230					86	37	139	4.0	566	207			487	13	.5	3.0		0.00											
		7/1/59	208		7.9	1190					88	35	127	3.3	567	191			447	11	.4	3.2		0.01											
		10/1/59	150		7.9	1360					99	44	154	3.7	673	[illegible]	0		561	11	.5	2.9		0.00											
		1/6/59	10		7.9	4670					260	175	702	6.4	2460	[illegible]			2460	41	.7	21		0.01											
		2/3/59	6		7.7	4580					268	175	690	6.1	2420	[illegible]			2380	44	.7	20		0.01											
		2/1/60	1		7.6	7090					402	281	1240	13	375	[illegible]	0		4180	55	.7	30		0.01											-
Pryor Mountains	07S 26E 21AA	2/17/74	9	36	8.6	476	390	11.40	1.50	<100	63	25	1.4		260	[illegible]	5	204	55	0.8		1.7	0.0	0.11	0.04	0.01	<.01	<.01		<.01				<25	12
	07S 26E 21AA	5/15/74	15	39	8.4	536	401	10.9	1.50	<100	67	22	1.8		260	[illegible]	5	212	56	0.1		.66	<.03	0.3	<.01	<.01	<.01	<.001		<.001	<.[illegible]			<25	22
near Warren	09S 25E 10CC	3/20/74	50	32	8.0	739	559	11.50		<100	75	34	30		[illegible]	[illegible]		185	190	4.0	.4	0.0	0.11	0.89	0.16	0.01	<.01	<.001		<.01	<.[illegible]			<25	
	09S 25E 10CC	5/30/74	62	54	8.2	677	527	9.3	1.65	115	63	28	42		[illegible]	[illegible]	0	174	173	9.0		.04	0.15	4.1	0.11	0.02	<.01	<.001		<.001				44	154

*See Appendix II

Fork Creek. Each of these streams were sampled near their confluences with Pryor Creek (Plate I, Figure 1).

Table 11 shows typical chemical analysis of surface waters in the Pryor Creek sub-basin. Table 11 shows that the values of sodium, sulfate, chloride, and total suspended sediment increase significantly for Pryor Creek from the upper station to the lower station. Water at the upper station is basically a calcium bicarbonate type whereas at the lower station sodium, sulfate, and occasionally chloride become prominent.

On January 16, 1974, the WQB made a water quality run on the Pryor Creek mainstem. Samples were collected from the upper and lower sites at Pryor and Huntley, and also at three sites spaced somewhat strategically between. The field data collected at these five sites included:

Q	Flow in cubic feet per second (cfs),
T	Temperature in degrees centigrade,
SC	Specific Conductance in micromhos/cm at 25°C,
pH	Standard units,
TSS	Total Suspended Sediment in mg/l,
DO	Dissolved Oxygen in mg/l.

This data is tabulated below:

Station	Q	T	D.O.	SC	pH	TSS
Pryor at Pryor	100	4.0	11.5	450	8.3	108
Pryor below Pryor	700	0.0	11.5	780	8.2	----
Pryor near Hardin	600	0.0	11.5	430	7.8	906
Pryor above Huntley	650	1.0	11.5	470	7.6	1270
Pryor at Huntley	650	2.0	11.5	500	8.2	1100

Of the tributary streams, Hay and East Fork of Pryor Creeks seem to be high in total suspended sediment concentrations. All of the tributary streams, Hay, East Fork of Pryor, and East Fork Creeks, have higher concentrations of sodium and sulfate than does Pryor Creek at Pryor. Since the flow of East Fork Creek is small compared to the flow of Pryor Creek, loading due to East Fork Creek is not significant. Loadings in tons/day of sodium, sulfate, and sediment for Pryor Creek at Pryor, East Fork of Pryor Creek, and Hay Creek based on the data collected May 15, 1974, are listed below:

Site	Sodium (T/day)	Sulfate (T/day)	Total Suspended Sediment (T/day)	Dissolved Solids (T/day)
Pryor Crk at Pryor	1.36	8.96	5.26	79.7
East Fork Pryor Crk	14.70	51.0	52.00	109.3
Hay Creek	1.29	3.40	7.11	12.4
Pryor Crk @ Huntley	120	430	170	474.3

YELLOWSTONE RIVER SUB-BASIN--PRYOR CREEK TO THE BIGHORN RIVER

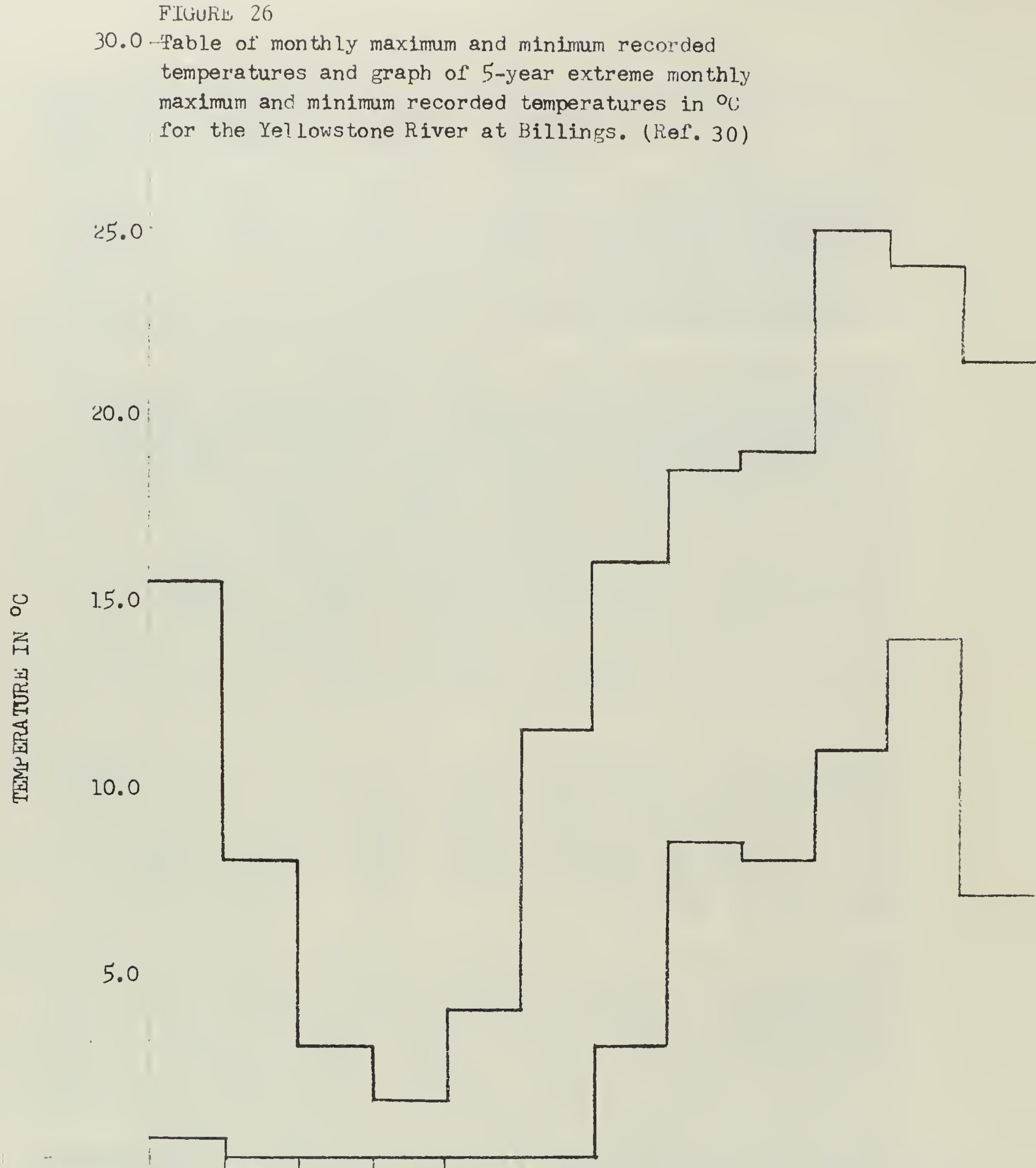
This sub-basin has been designated B_7D_3 by the Water Quality Bureau (WQB) (Appendix B). The Yellowstone River is the major stream in this sub-basin. The USGS maintained a sampling station on the Yellowstone River at Custer in water year 1970, at Huntley in water year 1972, and maintains another at Billings. The Billings station is slightly outside of the Middle Yellowstone sub-basin but is the major stream entering the region. The WQB sampled the Yellowstone River in this sub-basin at Huntley, Pompeys Pillar, and Custer during water years 1967 and 1968. In addition, two sampling sites were established by the WQB in water year 1974 on the Yellowstone at Huntley and Custer. Three minor streams, all tributaries to the Yellowstone River in this sub-basin, were sampled by the WQB; these were Pryor Creek, Arrow Creek, and Fly Creek.

Sampling sites on Pryor Creek are those described previously. The sampling site on Arrow Creek was near its confluence with the Yellowstone while the sampling site established on Fly Creek corresponded to the water quality sampling site of the USGS on this stream. Water quality data collected by the USGS in water year 1973 has not been published to date.

Figure 26 includes a table of the monthly maximum and minimum recorded water temperatures for the period of October 1968 to September 1972 plus a graph of the 5-year extreme monthly maximum and minimum temperatures for the Yellowstone River at Billings. Table 12 shows typical chemical analysis of surface waters in the Yellowstone River sub-basin--Pryor Creek to the Bighorn River. Quality data (Table 12) indicate no drastic changes in concentrations of the specific parameters for the Yellowstone River between Billings and Custer although specific conductance and dissolved solids show a slight increase. All three tributaries demonstrate distinctly larger concentrations of dissolved constituents, particularly sodium and sulfate, than the Yellowstone River.

FIGURE 26

Table of monthly maximum and minimum recorded temperatures and graph of 5-year extreme monthly maximum and minimum recorded temperatures in °C for the Yellowstone River at Billings. (Ref. 30)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1968	15	6	0	0	0	9	16	18	17	23	23	19
	4	0	0	0	0	0	3	8	9	11	14	10
1969	14	7	1	1	1	9	16	16	18	25	24	21
	6	1	0	0	0	0	5	9	9	15	17	12
1970	15.5	8.0	2.0	0.0	4.0	7.0	11.5	18.5	16.5	23.0	23.5	21.5
	3.0	0.5	0.0	0.0	0.0	0.5	4.0	8.5	8.0	12.0	17.0	7.0
1971	15.0	6.0	3.0	1.0	1.0	9.5	----	18.0	15.5	20.5	24.0	20.5
	2.0	0.0	0.0	0.0	0.0	0.0	5.5	----	9.0	12.0	17.0	9.5
1972	14.0	6.5	2.0	1.5	0.5	11.5	15.0	18.5	19.0	23.0	24.0	15.5
	0.5	0.5	1.0	0.0	0.0	0.5	5.0	8.5	11.5	12.0	16.5	11.5

Table 11

Typical chemical analysis of surface waters in the Pryor Creek sub-basin.

Sampling Site Designation	Sampling Site Location *	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25° C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness $CaCO_3$ (mg/l)	Bicarbonate HCO_3 (mg/l)	Carbonate CO_3 (mg/l)	Alkalinity $CaCO_3$ (mg/l)	Sulfate SO_4 (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO_3 (mg/l)	Phosphate PO_4 (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
Pryor Creek																																			
near Huntley	01N 28E 19BD	7/4/73		21.6	8.4	804	666	8.00	1.80	400	62	45	54		341	317	2	268	162	22	.41	1.8	0.06	0.11			<.01	<.001	0.04	<.01			1.3	57	
at Huntley	02N 27E 25CD	7/11/73		29.4	8.30	982	722.	27.8	3.00	110	66	45	73		352	268	0	220	262	7.0	.50	.22	0.04	0.12			0.02	<.01	<.01	<.01			1.7	<25	
	02N 27E 25CD	11/8/73		0.0	8.1	956		12.4	2.6																									25	74
	02N 27E 25CD	1/16/74	600	2.2	8.2	534		11.3																										160	1100
near Huntley	01N 28E 19BD	1/22/74	580		8.4	989	754	12.6	4.0	140	85	35	78		355	263	6	226	276	8.2		3.0	0.24	5.5	0.42	0.01	0.01	<.001			.007		1.8		108
at Huntley	02N 27E 25CD	3/14/74	106	2.2	8.2	1050	850	13.0	3.4		79	38	113	34	354	278	0	228	332	8.4	.46	.29	0.26	11.9	1.0	0.09	0.01	<.001	<.01	<.01			2.6	135	1720
	02N 27E 25CD	4/17/74	220	10.0	8.1	1110	797	10.0	3.4		60	32	128		279	203	0	167	348	27															3436
	02N 27E 25CD	6/6/74	224	13.0	8.6	853	670			1060	81	33	60		339	267	16	245	206	6.3		.47	0.13	5.5	0.53	0.03	<.01	<.001			<.001			150	430
at Pryor	05S 26E 05AB	1/16/74	103	0.0	8.2	818		11.7																											108
	05S 26E 05AB	3/20/74	31	0.0	8.4	501	424	13.3		400	58	22	12	12	235	278	7	240	34	0.0	.31	0.0	0.06	0.18	0.02	<.01	<.01	<.001					0.3		26
	05S 26E 05AB	5/15/74	72	7.2	8.2	480	409	10.7	1.8	95	60	24	7.0		249	267	3	224	46	0.6		.60	<.03	0.47	0.04	<.01	<.01	<.001		<.001	<.001				27
Tributaries																																			
East Fork near Pryor	05S 27E 13AB	3/20/74	13	0.0	7.9	1110	892	13.1		$>10^2$	84	26	115	34	317	228	0	187	400	4.0	.42	.17	0.06	6.4	0.70	0.04	0.01	<.01		<.01					176
	05S 27E 13AB	5/15/74	45	6.4	8.2	1230	898	10.3	3.6	$>10^2$	93	31	121		361	229	0	188	419	4.1		.50	0.18	21	1.7	0.14	0.02	<.001		<.001	<.001			120	427
Hay Creek near Pryor	04S 27E 21AA	3/20/74	5	0.0	8.1	910	761	12.8	3.8	$<10^2$	75	32	80	25	317	282	0	231	260	8.0	.35	.03		1.5	0.25	<.01	<.01	<.001		<.01			2.0	31	68
	04S 27E 21AA	5/15/74	9	5.6	8.1	671		10.3	3.0	$>10^3$	55	20	53		218	238	0	195	140	1.1		.5	0.15	13	0.9	0.10	0.02	<.001		<.001	<.001			46	292
East Fork Creek near Hardin	01S 28E 30DC	5/30/74	2	10.6	8.2	5030	4567	9.9	2.3	$>10^3$	228	243	800		1570	430	6	363	2820	40		0.0	0.03	0.55	0.11	0.01	<.01	<.001		.002				4	16.0

* See Appendix II

Loads of selected parameters shown below are tabulated in tons per day for the Yellowstone River at Billings, for Pryor Creek at Huntley, and for Fly Creek at Pompeys Pillar. Samples used in determining loads for each of these streams were chosen at a period when the Yellowstone River had a relatively low flow while the two tributary creeks had relatively high flows. The sample collected on January 7, 1970, by the USGS on the Yellowstone River at Billings, the sample collected on January 22, 1974, by the WQB on Pryor Creek at Huntley, and the sample collected on January 30-31, 1971, by the USGS on Fly Creek at Pompeys Pillar were used to determine the loads (see Table 12). From this information it seems that Pryor Creek could have a significant influence on water quality of the Yellowstone River.

Daily loading in tons/day of listed parameter:

	Na	HCO_3	SO_4	Cl	Fe	TSS	TDS	FLOW
Yellowstone River at Billings	144	727	425	32	0.6	104	1350	1330
Pryor Crk at Huntley	120	410	430	13	8.6*	170	1180	580
Fly Crk at Pompeys Pillar	38	85	94	4.0	0.2	---	----	266

*total recoverable iron

LITTLE BIGHORN RIVER SUB-BASIN

The State Department of Health and Environmental Sciences has designated the portion of this sub-basin including Lodge Grass Creek as $B\text{-}D_1$. The remainder of this sub-basin has been designated as $B\text{-}D_2$ (Appendix I). The Little Bighorn River is the major stream in this sub-basin and several tributary creeks contribute significant amounts of water especially during a high flow.

The USGS maintains two water quality stations on the Little Bighorn River--near Wyola and near Hardin. The USGS also had a station at Crow Agency. The Water Quality Bureau (WQB) established stations on the major tributaries to the Little Bighorn River; they were Pass Creek, Owl Creek, and Lodge Grass Creek. The WQB established sampling sites on Lodge Grass Creek and on Pass Creek near their respective confluences with the Little Bighorn. A sampling site was also established at the mouth of Owl Creek; in addition, a set of samples was collected from three of the forks of Owl Creek's upper drainage. Several minor tributaries of the Little Bighorn River were sampled near their confluences--Spring, Grey Blanket, and Reno Creeks (Plate I, Figure 1).

Table 12
Typical chemical analysis of surface waters in the Yellowstone River sub-basin--
Pryor Creek to Bighorn River

Sampling Site Designation	Sampling Site Location *	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25° C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness $CaCO_3$ (mg/l)	Bicarbonate HCO_3 (mg/l)	Carbonate CO_3 (mg/l)	Alkalinity $CaCO_3$ (mg/l)	Sulfate SO_4 (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO_3 (mg/l)	Phosphate PO_4 (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadmium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
Yellowstone River	Mainstem																																		
at Billings	01S 26E 02CD	6/11/68	33400	12.5	7.7	199					21	[illegible]	[illegible]	1.8		94	0.0		24	2.1	0.1	0.3		.04											
	01S 26E 02CD	6/3/70	24100	15.5	7.3	225	133				22	[illegible]	11	1.7		94	0.0		27	2.4	0.3	0.01	.04	.05		0.02	0.04	[illegible]	[illegible]	0.00					120
	01S 26E 02CD	6/6/72	41300	15.0	7.0	118	78				14	[illegible]	5.8	1.3		56	0.0		12	[illegible]	0.1			.08											
	01S 26E 02CD	1/7/70	1330	0.0	7.9	602	376				50	20	40	6.1		202	0.0		118	9.0	0.7	0.58		.17											29
	01S 26E 02CD	3/2/71	2940	0.5	8.6	440	270				43	15	28	3.7		171	0.0		70	8.5	0.5			.14											
	01S 26E 02CD	1/14/72	2180	0.0	7.9	465	294				45	15	26	3.2		171	0.0		89	10	0.5			.03											
at Huntley	02N 27E 24A	8/8/72	8020	21.5	8.2	320		8.0	1.7	2×10^3		9.6	19					98	56	5.2	0.6														
	02N 27E 24A	8/14/51			7.3	309					28	9.2	20			117			45	4.5	0.2	2.0		.02											
	02N 27E 24A	4/25/74	5700	14.0	8.0	378	276	8.9	2.6	24	37	11	22		136	137	0.0	112	64	4.6		0.67	0.14	1.5	0.10	0.01	<.01	<.001			.001		0.8	26	81
	02N 27E 24A	8/14/67	6700	21.5			206				24	15	33			140	0.0		58	11	0.7	0.35		0.16										<25	
at Pompeys Pillar		8/14/67	6700	22.5			220				26	5	56			146	0.3		71	9	0.7	0.31		0.28										<25	
At Custer	05N 33E 35DA	8/14/67		22.5	7.5		226				32	9	37			146	0.0		70	8	0.67	0.35		0.48										<25	
	05N 33E 35DA	8/25/69	3550	22.5	8.4	471		7.6	24									131	96			0.00												10	
	05N 33E 35DA	2/16/70	2900	0.0	7.8	430		11.2	8.1									144	97															10	
	05N 33E 35DA	6/15/70	27500	14.5	7.5	280		9.4	1.7									82	59															150	
	05N 33E 35DA	1/22/74	4200	0.0	7.7	528	362	12.3	4.1	40	53	8	33		167	154	0.0	127	103	7		3.3		0.82	0.05	<.01	<.01	<.01			<.001		1.1	20	46.0
	05N 33E 35DA	4/25/74	5700	15.2	7.9	403	287	8.9	2.6	66	39	11	25		143	141	0.0	116	64	6.0		0.77	0.15	1.3	0.10	<.01	<.01	<.001			<.001	<.01	0.9	30	73
Tributaries																																			
Arrow Creek	02N 29E 08AD	11/8/73	0.3	0.0	8.3	1650	1320	13.1	2.4		104	73	168			397	0.0		568	4	0.3	2.5	0.01	0.16		0.07	0.01	<.01	<.01	<.01			3.1	<25	
	02N 29E 08AD	3/14/74	2.0	2.0	8.1	1420	1130	14.1	3.2	$<10^2$	88	66	136			357	0.0		469	13	0.3	0.13	0.11	0.41	0.04	0.01	0.01	<.01	<.01	<.01			2.7	<25	22
	02N 29E 08AD	6/6/74	2.0	10.5	8.2	1390	1078	11.1	[illegible]		85	65	128		179	363	0.0	298	426	11.7		0.11	<.03	0.27	0.02	<.01	<.01	<.001		<.001	<.001		2.5	<25	8
Fly Creek	03N 30E 23BD	3/16/69	2050	0.0	7.4	312					26	9	20	7.5		94			67	2	0.2	0.5		0.63											
	03N 30E 23BD	1/30-31/71	266		8.0	489					30	13	53	5.8		118	0.0		130	5.5	0.2		0.10	0.22											
	03N 30E 23BD	6/15/71	96	17.5	7.7	532					31	18	49	2.1		130	0.0		150	3.7	0.4		0.06	0.04											
	03N 30E 23BD	12/5/68	6.2	1.0	8.1	2240					121	92	285	5.0		470	0.0		915	14	0.5	1.5		0.24											
	03N 30E 23BD	12/3/69	7.2	2.0	8.1	2320	1760				102	96	326	5.6		392	0.0		995	19	0.6			0.16											
	03N 30E 23BD	12/6/71	6.6	2.0	8.0	2250	1720				130	91	300	4.5		477	0.0		930	15	0.5			0.01											
	03N 30E 23BD	9/8/69	47	14.0	7.6	1080					76	36	119	4.6		296	0.0		350	8.2	0.7	0.1		0.08											
	03N 30E 23BD	9/3/70	59	16.0	7.7	1010	712				73	38	106	5.4		290	0.0		320	8.4	0.6			0.05											
	03N 30E 23BD	9/5/72	54	15.0	7.9	926	611				62	34	90	3.3		244	0.0		280	7.4	0.5			0.02											
	03N 30E 23BD	11/8/73	21	2.0	7.9	2120	1790	13.1	[illegible]		101	58	289			463	0.0		843	0.5	0.5	2.1	0.05	0.14		0.02	<.01	<.01	<.01	<.01			5.1	<25	
	03N 30E 23BD	3/14/74	8.0		8.2	2920	2410	13.0	[illegible]	10^2	137	[illegible]	450			444	0.0		1262	25	0.44	0.16	0.08	0.33	0.21								7.3	<25	15
	03N 30E 23BD	6/6/74		15.0	7.9	750	548	8.7	[illegible]		[illegible]	[illegible]	73			139	2	118	250	5.1		0.23	0.09	3.4	0.15	0.01	<.01	<.001			.001		2.4	47	168

* See Appendix II

Table 13 shows typical chemical analysis of surface waters in the Little Bighorn sub-basin. Specific conductance values and dissolved solid concentrations are slightly higher for the major tributaries and considerably higher for the minor tributaries than for the river. This is most noticeable for sodium and sulfate. Pass Creek and Owl Creek are both significant contributors to the suspended sediment loads in the Little Bighorn River during high flow periods. The loads of selected parameters have been tabulated in tons per day for the Little Bighorn River at the state line, for Pass Creek near Wyola, and for Owl Creek near Lodge Grass. Since these streams have their peak runoff in the spring, data collected during this period was used to determine the loads. Loads summarized below were determined from samples collected in May, 1974. Tributary creeks have a significant effect on water quality in the Little Bighorn River

	Load in tons/day			
	Na	SO_4	TSS	TDS
Little Bighorn River at state line	0.8	7.4	5.3	150
Pass Creek near Wyola	7.6	29	72	150
Owl Creek near Lodge Grass	5.6	16	17	75
Lodge Grass Creek near Lodge Grass	2.7	11	1	25

Table 13 shows a general increase in the concentrations of dissolved constituents for the Little Bighorn River mainstem from the state line to Hardin. This is indicated by an increase in sediment, specific conductance, and calculated dissolved solids. Sodium and sulfate show the largest increases.

Figure 27 includes a table of the monthly mean sediment concentrations for the Little Bighorn River near Hardin. An interesting feature is the high concentration in early spring rather than during the peak runoff. This suggests that the relatively high flows created by runoff from the prairie drainage during early spring produce the higher concentrations of suspended sediment. The larger loads, however, probably still occur during the peak runoff period due to high flows.

Figures 28 and 29 include tables of monthly maximum and minimum recorded temperatures and graphs of 3-year extreme monthly maximum and minimum temperatures for the Little Bighorn River near Wyola and for the river near Hardin. On the average, it appears that higher water temperatures are experienced at the lower station.

Table 13

Typical chemical analysis of surface waters in the Little Bighorn River sub-basin

Sampling Site Designation	Sampling Site Location *	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25° C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness $CaCO_3$ (mg/l)	Bicarbonate HCO_3 (mg/l)	Carbonate CO_3 (mg/l)	Alkalinity $CaCO_3$ (mg/l)	Sulfate SO_4 (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO_3 (mg/l)	Phosphate PO_4 (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
Little Bighorn River Mainstem																																			
near Wyola	07S 35E 35CC	6/10/70	1820	9.5	8.0	360	195				48	14	6.2	1.6		200	0		19	0.6	.2			.050											
	07S [illegible] 35CC	[illegible]2/7.	850	11.0	8.0	389	231				51	17	7.8	0.7		204	0		46	0.8	.2			.030											
	07S 35 35CC	7/1/72	860	14.5	7.8	348	201				47	14	5.8	0.8		184	0		36	0.3	.2			.030											
	07S 35E 35CC	12/4/69	128	2.0	7.7	596	350				66	27	20	1.1		252	0		103	1.2	.1			.017											
	07S 35E 35CC	12/2/70	153		8.3	602	377				70	28	23	1.5		270	0		110	1.2	.2			.040											
	07S 35E 35CC	12/2/71	92	0.0	7.9	639	398				76	30	22	1.4		264	0		130	1.0	.1			.000											
	07S 35E 35CC	9/16/70	209		7.9	673	375				70	24	25	1.8		268	0		111	1.2	.2			.064											
	07S 35E 35CC	9/1/71	115	19.0	8.1	649	404				70	31	27	2.2		288	0		120	1.7	.7			.030											
near Hardin	01S 34E 19AA	6/10/70	2060	17.0	8.0	474	290				67	30	36	3.0		266	0		154	2.3	.2			.013											
	01S 34E 19AA	6/2/71	1080	13.5	7.9	550	332				52	24	27	1.7		242	0		100	1.5	.2			.030											
	01S 34E 19AA	6/3/72	1170	20.5	7.4	434	256				48	19	13	1.5		212	0		61	1.9	.1			.030											
	01S 34E 19AA	12/4/69	154	1.5	7.8	748	486				64	38	49	2.5		285	0		182	2.6	.2			.160											
	01S 34E 19AA	12/2/70	320		8.3	797	509				74	36	48	2.6		307	0		190	2.6	.3			.000											
	01S 34E 19AA	12/3/71	124	1.5	8.0	856	561				81	41	58	2.3		298	0		220	4.4	.2			.010											
	01S 34E 19AA	9/15/70	292		8.1	660	432				67	30	36	3.0		266	0		154	2.3	.3			.013											
	01S 34E 19AA	9/14/71	151	17.0	8.1	694	452				57	35	42	2.5		258	0		180	1.5	.2			.020											
	01S 34E 19AA	9/5/72	148	19.0	8.1	656	411				57	32	38	2.1		229	0		160	3.2	.2			.200											
at MT/WY state	09S 33E 36CB	3/21/74	65	0.0	8.30	350	322	12.3		0	46	15.[illegible]	9.4	8	180	209	12	191	22	0.2	.12	0.0	.05	.13		<.01	<.01	<.01	<.01				0.3	1	0
line	09S 33E 36CB	5/1/74	218	5.4	8.32	314	267	10.9	1.5	20	44	14.[illegible]	1.3		170	189	4	162	12.5	0.3		0.52	.06	.03	<.01	<.01	<.01	<.001			<.001		0.0	6	9.0
near Wyola	07S 35E 35CC	12/20/73	110	1.0	8.52		601	13.4	2.5	3														.13	,	<.01	<.01	<.01	<.01					2	
	07S 35E 35CC	2/15/74	121	4.0	8.01	653	526	12.3	3.2	0	75	30	24		309	259	0	212	138	.04		0.68	0.0	.30	0.06	<.01	<.01	<.01			<.001		0.6	10	22.3
	07S 35E 35CC	4/3/74	141	5.0	8.37	692	566	12.5	2.8	9	63	38	40		313	247	6	212	172	0.2	.19	0.0	0.03	.29	0.05	<.01	<.01	<.01		<.01	<.001		1.0	8	18.6
	07S 35E 35CC	5/14/74	461	8.8	8.31	482	385	11.5	2.[illegible]	12	63	19	12		234	223	5	190	63	0.2		0.13	0.04	.70	0.05	0.01	<.01	<.001			<.001	<.01	0.3	14	46.5
near Hardin	01S 34E 19AA	2/15/74	265	0.0	8.04	1450	737	12.1	2.3	70	77	42	64		366	299	0	246	250	2.4		1.5	0.56										1.5	23	56.5
	01S 34E 19AA	3/6/74	256	3.1	8.20	984	788	12.5	3.5	25	77	46	78		381	296	4	249	285	3.0		0.42	0.82	2.5		0.02	0.01	<.01	<.01	<.01	<.001	0.01	1.7	52	122
	01S 34E 19AA	5/14/74	482	11.8	8.31	602	492	10.7	2.5	28	61	29	28		271	245	5	209	122	2.0		0.07	0.05	1.8	0.08	0.02	<.01	<.001		<.001	<.001	<.01	0.7	41	123
(middle)		5/14/74	472E	11.2	8.26	562	455	10.8	2.5	51	61	27	23		261	237	7	206	100	1.0		0.08	0.05	1.4	0.06	0.01	<.01	<.001			<.001		0.6	24	86.7
Tributaries																																			
Spring Creek	09S 34E 30ABD	4/3/74	2.0	8.0	7.65	837	692	12.4	1.2	0	117	40	13		458	253	0	205	268	0.2	.14	0.24	0.03	.03	<.01	<.01	<.01	<.01		<.01	<.001		0.3	0	4.0
Pass Creek	08S 35E 22ACD	3/21/74	20.8	0.0	8.20	1023	856			4	83	37	85	27	359	298	0	244	325	1.0	.18	0.0	<.03	1.8	0.08	0.01	<.01	<.001		<.01			2.0	30	58.0
	08S 35E 22ACD	5/1/74	117	10.0	8.33	601	494	9.70	1.5	580	67	27	24		280	278	4	234	92	1.4		0.60	0.07	2.5	0.14	0.02	<.01	<.001			<.001		0.6	53	226
Upper Owl Creek	07S 36E 34AA	5/15/74	15.0	10.5	8.25	769	648	10.0	2.1	171	58	41	53		313	406	0	333	87	2.0		0.0	0.05	.12	0.09	0.01	<.01	<.001			<.001		1.3	34	87
East Owl Creek	07S 36E 11BC	5/15/74	17.7	9.0	8.23	970	803	10.6	2.5	600	86	71	20		507	423	0	347	200	2.0		0.77	0.12	2.1	0.15	0.02	<.01	<.001			<.001		0.4	53	146
Sioux Pass Creek	07S 36E 03BC	5/15/74	6.5	9.3	8.21	992	829	12.2	2.3	18	68	76	41		464	419	7	364	201	3.0		0.0	<.03	.18	0.05	0.01	<.01	<.001			<.001		0.8	3	8.6
Owl Creek	06S 36E 30AB	2/15/74	17.6	0.0	8.13	1156	791	11.5	2.4	30	71	53	60		394	432	0	370	150	2.4		3.3	0.23	.57		<.01	<.01	<.01	<.01		<.001		1.[illegible]	16	33.6
	06S 36E 30AB	5/1/74	35.3	10.2	8.24	906	791	9.3	1.7	30	67	57	59		400	436	0	357	168	3.6		0.50	0.08	<.01	0.04	0.01	<.01	<.001			<.001	<.01	1.3	60	182
Grey Blanket Creek	06S 36E 19AA	5/15/74	5.0	9.7	8.28	1036	861	11.5	2.2	53	70	76	49		489	418	15	367	230	3.0		0.27	<.03	.20	0.03	<.01	<.01	<.001			<.001		1.0	5	14.2
Lodge Grass Creek	06S 35E 13DA	11/20/73	48.5	0.0	7.51	843	659	12.9	2.6	6	92	38	33		385	256	0	210	238	1.2		0.11	0.52	.41		<.01	<.01	<.01	<.01	<.01			0.7	9	
	06S 35E 13DA	2/15/74	55.4	0.0	7.97	909	713	12.3	1.1	30	100	38	48		407	217	5	186	303	1.6		0.31	0.01	.51	0.04	<.01	<.01	<.01			0.001		1.0	13	28.5
	06S 35E 13DA	4/3/74	18.0	5.8	8.22	1332	1108	12.0	2.9	0	110	63	113		534	320	0	262	497	4.8	.21	0.0	<.03	.23	0.05	<.01	<.01	<.01		<.01	0.001		2.1	3	7.0
	06S 35E 13DA	5/15/74	6.8	11.9	8.11	1588	1297	10.2	1.7	10	119	75	144		609	338	6	287	607	6.8		0.0	<.03	.25	0.05	<.01	<.01	<.001		<.001	<.001	<.01	2.5	2	6.0
Reno Creek	04S 36E 11AC	5/14/74	1.3	13.3	8.48	1414	1215	12.6	3.5	55	45	60	208		360	637	26	566	238	0.2		0.0	0.06	.41	0.05	0.01	<.01	<.001			<.001		4.8	7	20.0

* See Appendix II

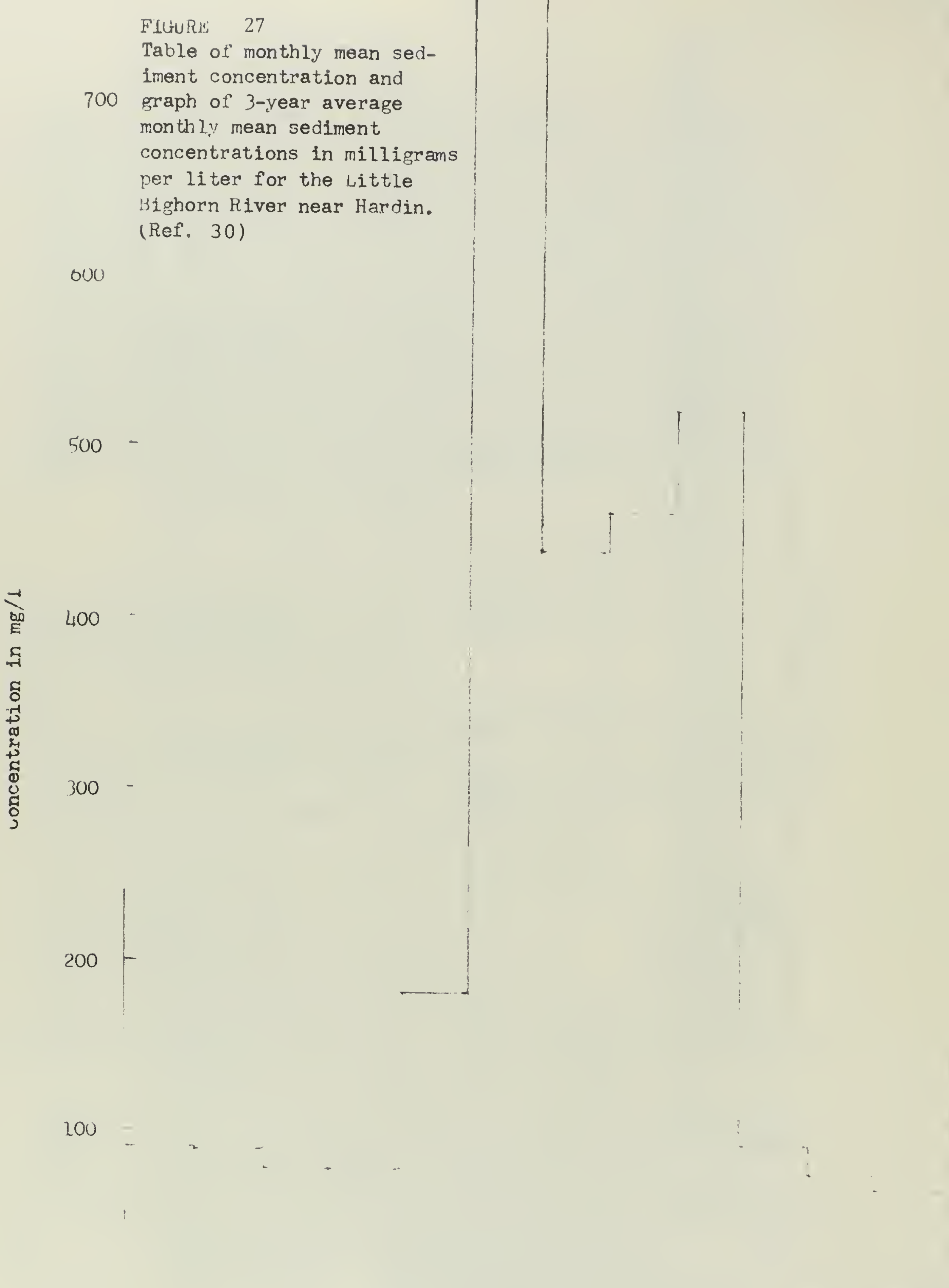


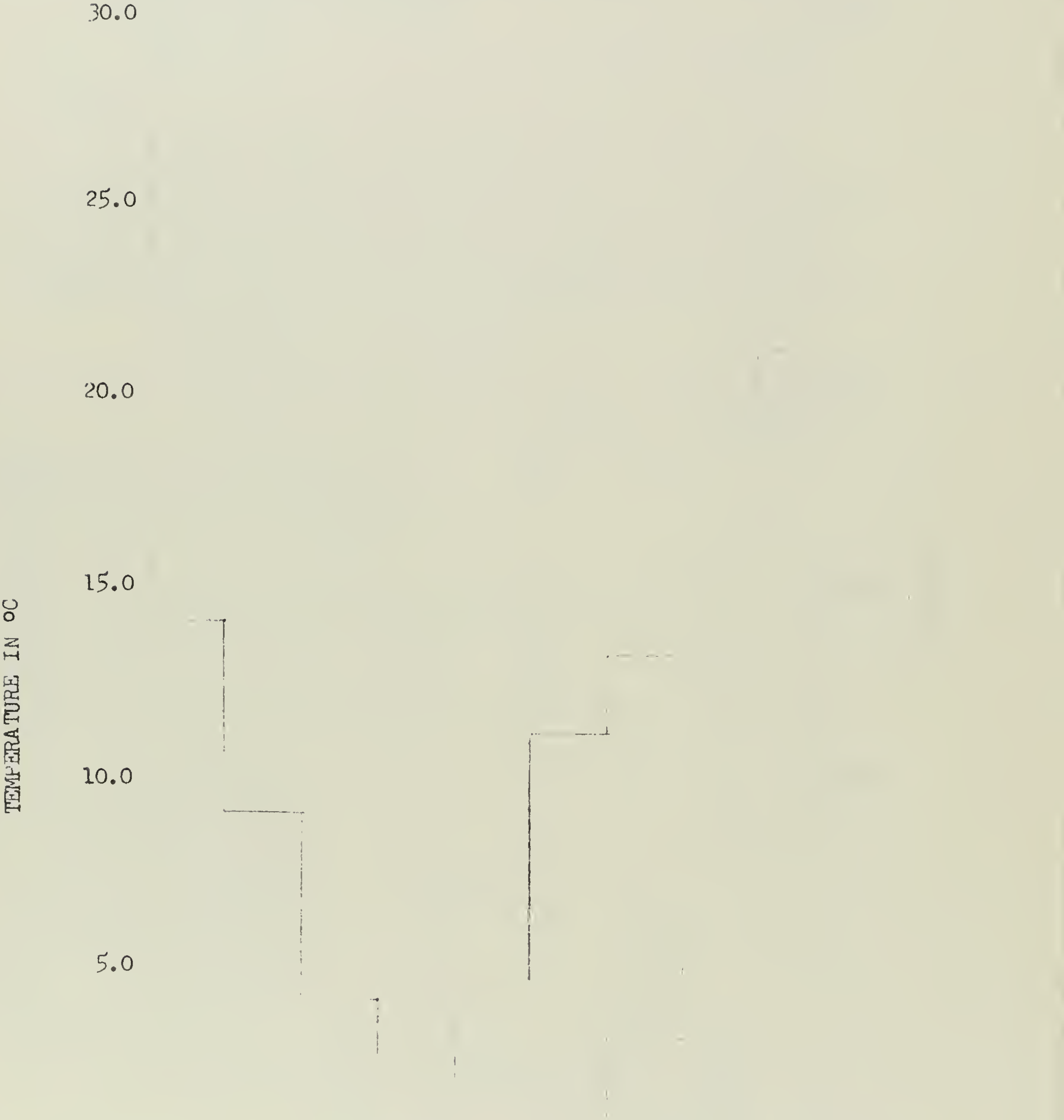
FIGURE 27
Table of monthly mean sediment concentration and graph of 3-year average monthly mean sediment concentrations in milligrams per liter for the Little Bighorn River near Hardin. (Ref. 30)

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1970	50	98	38	80	95	200	501	692	475	97	64	77
1971	43	69	88	75	120	964	687	357	534	87	65	72
1972	176	101	104	75	332	1170	129	337	557	90	93	42
Average	90	89	77	77	182	778	439	462	522	91	74	64

FIGURE 28
Table of monthly maximum and minimum recorded temperatures and graph of 3-year extreme monthly maximum and minimum recorded temperatures in °C for the Little Bighorn River near Hardin. (Ref. 30)

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1970	19.5	8.0	2.0	3.0	3.0	5.0	13.0	20.0	21.0	28.0	27.0	24.0
	3.0	1.0	0.0	0.0	0.0	0.0	4.0	10.0	15.0	23.0	21.0	7.5
1971	15.0	5.0	0.0	0.0	0.0	6.5	15.0	18.0	25.0	28.0	30.0	24.0
	4.0	0.0	0.0	0.0	0.0	0.0	6.5	12.0	15.0	19.5	24.5	12.5
1972	13.0	4.5	2.5	2.0	2.0	14.5	18.5	24.0	27.0	27.5	27.5	23.0
	4.0	0.0	0.0	0.0	0.0	0.0	5.0	10.0	19.0	15.0	18.0	8.0

FIGURE 29
Table of monthly maximum and minimum recorded temperatures and graph of 3-year extreme monthly maximum and minimum recorded temperatures in °C for the Little Bighorn River near Wyola. (Ref. 30)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1970	14.0	9.0	4.0	2.0	4.5	6.0	9.5	13.0	18.5	20.0	22.5	18.0
	3.0	0.0	0.0	0.0	0.0	0.0	3.0	6.0	8.0	13.0	15.5	6.0
1971	12.5	6.5	4.0	1.0	2.0	8.0	12.0	14.5	20.0	22.5	22.5	19.5
	2.5	0.0	0.0	0.0	0.0	0.0	3.0	8.0	9.5	12.5	15.5	7.0
1972	14.0	7.5	1.0	0.0	4.5	11.0	13.0	15.5	21.0	21.0	22.5	17.0
	0.0	0.0	0.0	0.0	0.0	0.0	5.0	7.0	10.5	10.5	15.0	7.0

BIGHORN RIVER SUB-BASIN

The Montana State Department of Health and Environmental Sciences has designated the Bighorn River drainage above but excluding Williams Coulee near Hardin as B-D_1. The remainder of this sub-basin has been designated as B-D_2. The upper reaches of the Little Bighorn River have been designated as B-D_1 with the lower reaches classified as B-D_2 (see Appendix B).

Surface water quality of Yellowtail Reservoir has been studied extensively (Ref. 16, 34). The Water Quality Bureau sampled six perennial creeks which drain into the reservoir in Montana--Black Canyon, Little Bull Elk, Big Bull Elk, Porcupine, Dry Head, and Hoodoo Creeks. Another stream, Crooked Creek, has the majority of its drainage in Montana but enters the reservoir in Wyoming.

The four creeks which flow out of the Bighorn Mountains seem to have generally good quality water (Table 14A). These are Black Canyon, Little Bull Elk, Big Bull Elk, and Porcupine Creeks. Specific conductance values were less than 350 umhos/cm @ 25°C. Concentrations of dissolved constituents in these creeks were well within the yearly variations documented for the reservoir (Ref. 16). Of particular interest are sulfate concentrations which were considerably lower for these streams. The remaining three streams flowing out of the Pryor Mountains--Hoodoo, Dry Head, and Crooked Creek--had higher conductivities which indicates larger concentrations of dissolved constituents. Dry Head and Hoodoo Creeks had significantly higher concentrations of calcium, sulfate, and sediment. With the exception of Crooked Creek, all these streams are accessible only via Yellowtail Reservoir and boat.

Table 14A shows water quality data for those six streams influent to Yellowtail Reservoir in Montana. Water quality data for Crooked Creek is on Table 14 in the tributaries section.

The USGS maintained water quality stations on the Bighorn near St. Xavier (Yellowtail Reservoir discharge) and at Hardin. The USGS also maintains a station at Bighorn. The WQB collected occasional samples at the previously maintained USGS site at Hardin and at the USGS site at Bighorn. The major tributary to the Bighorn River is the Little Bighorn River. Both the USGS and the WQB sampling sites on the Little Bighorn River have been discussed in the previous sub-section, Little Bighorn River sub-basin. The remaining tributaries of importance to water quality in the Bighorn

Table 14A

Water quality of influent streams to Bighorn Lake (May 4-5, 1974). 1-Dry Head Creek; 2-Hoodoo Creek; 3-Porcupine Creek; 4-Big Bull Elk Creek; 5-Little Bull Elk Creek; 6-Black Canyon Creek.

Site	Flow	Temp	pH	k_{25}	CDS	DO	BOD	F.C.	Turb	TSS
1.	23	13.0	8.10	700	563	9.8	1.6	4	30	80
2.	6	11.0	8.30	939	764	10.2	2.0	3	11	35
3.	58	11.0	8.30	307	243	11.2	2.2	0	7	16
4.	72	10.0	8.30	327	265	10.1	1.3	0	2	7
5.	12	9.0	8.38	343	283	11.1	2.1	0	2	6
6.	168	7.5	8.41	330	278	11.1	2.0	0	2	6

Site	Ca	Mg	Na	K	T.H.	HCO_3	CO_3	T.A.	SO_4	Cl	F
1.	90	32	13		358	224	0	184	202	1.4	
2.	141	40	13		516	185	5	160	378	1.8	
3.	46	9	6		152	149	2	126	29	1.6	
4.	44	15	1		172	190	6	165	8	0.6	
5.	49	14	1		182	205	6	178	7	0.3	
6.	45	16	1		177	200	0	164	8	6.6	

Site	NO_3	PO_4	Fe	Mn	Cu	Zn	Cd	Hg	SAR
1.	0.21	<.03	0.75	0.07	<.01	0.01	<.001	<.001	0.3
2.	0.50	<.03	0.30	0.02	<.01	0.02	<.001	<.001	0.2
3.	0.12	<.03	0.18	0.01	<.01	<.01	<.001	<.001	0.2
4.	0.41	<.03	<.01	0.01	<.01	0.01	<.001	<.001	0.0
5.	0.21	<.03	0.05	<.01	<.01	<.01	<.001	<.001	0.0
6.	1.1	0.12	0.01	<.01	<.01	<.01	<.001	<.001	0.0

CDS - calculated dissolved solids
F.C. - fecal coliforms
T.H. - total hardness
T.A. - total alkalinity
k_{25} - specific conductivity in micromohs/cm @ 25° C

River are Soap, Rotten Grass, Beauvais, and Tullock Creeks. The USGS maintains a sampling station on Beauvais Creek about 14 miles above its confluence with the Bighorn River. The WQB established sampling sites on the three remaining streams at their respective confluences with the Bighorn River. A site was also established on the upper reach of Tullock Creek near Hardin (Plate I, Figure 1).

Table 14 shows typical chemical analysis of surface waters in the Bighorn River sub-basin. Only data on the Bighorn River mainstem after regulation by Yellowtail Reservoir has been considered. The data for any one station on the Bighorn River shows very little variation in concentration with changes in flow. This is probably due to the fact that the variation in flow is relatively small and that the water being discharged from the reservoir is not taken from the surface but approximately 150 feet below the surface. A characteristicly high sulfate concentration is present in the Bighorn River. Chloride concentrations are also high as compared to the Little Bighorn River sub-basin.

There is little change in the concentration of dissolved constituents from the station near St. Xavier to the station at Bighorn. This indicates that streams tributary to the Bighorn River generally have a negligible effect on the water quality of the Bighorn. There is an apparent increase in the concentration of suspended sediment between these two stations which could possibly be due to the combined effects of the tributary streams.

Figures 30 and 31 include tables of the monthly maximum and minimum recorded temperatures and graphs of the extreme monthly maximum and minimum recorded temperatures for the Bighorn River near St. Xavier and at Bighorn. These figures show that the monthly maximum temperature increases from the upstream station to the downstream site. Variations in extreme monthly maximum and minimum temperatures are smaller for the upstream station than the downstream station. Also, at the upstream station near Yellowtail Dam, extreme monthly minimum temperatures apparently do not reach 0°C in the winter. This is consistent with the fact that the water discharged from the reservoir is taken from below the water surface.

Figure 32 contains a table of the monthly mean suspended sediment concentrations in mg/l for the Bighorn River at Bighorn. There seems to be a period in the early spring when runoff from the prairie portion of the drainage causes a slight and temporary increase in the sediment concentration of the Bighorn River at Bighorn. A similar case was observed for the Little Bighorn River. However, maximum mean monthly concentrations in the Bighorn River apparently occur when tributary streams from mountainous drainages have their peak runoff (May and June). For the Little Bighorn, peak sediment loads occur in March correlated with the prairie runoff.

Rotten Grass, Beauvais, and Tullock Creeks have higher specific conductivities than the Bighorn River (Table 14). This shows higher concentrations of dissolved constituents in these tributaries. General concentrations of common ions are larger in tributary streams than the Bighorn River. Dissolved constituents with high concentrations are calcium and sulfate in Rotten Grass Creek; calcium strontium, and sulfate in Beauvais Creek; and sodium, alkalinity, and sulfate in Tullock Creek. Concentrations of common ions are lower in Soap Creek and in the Little Bighorn River than in the Bighorn River. Suspended sediment concentrations are significant during runoff periods for all the tributaries.

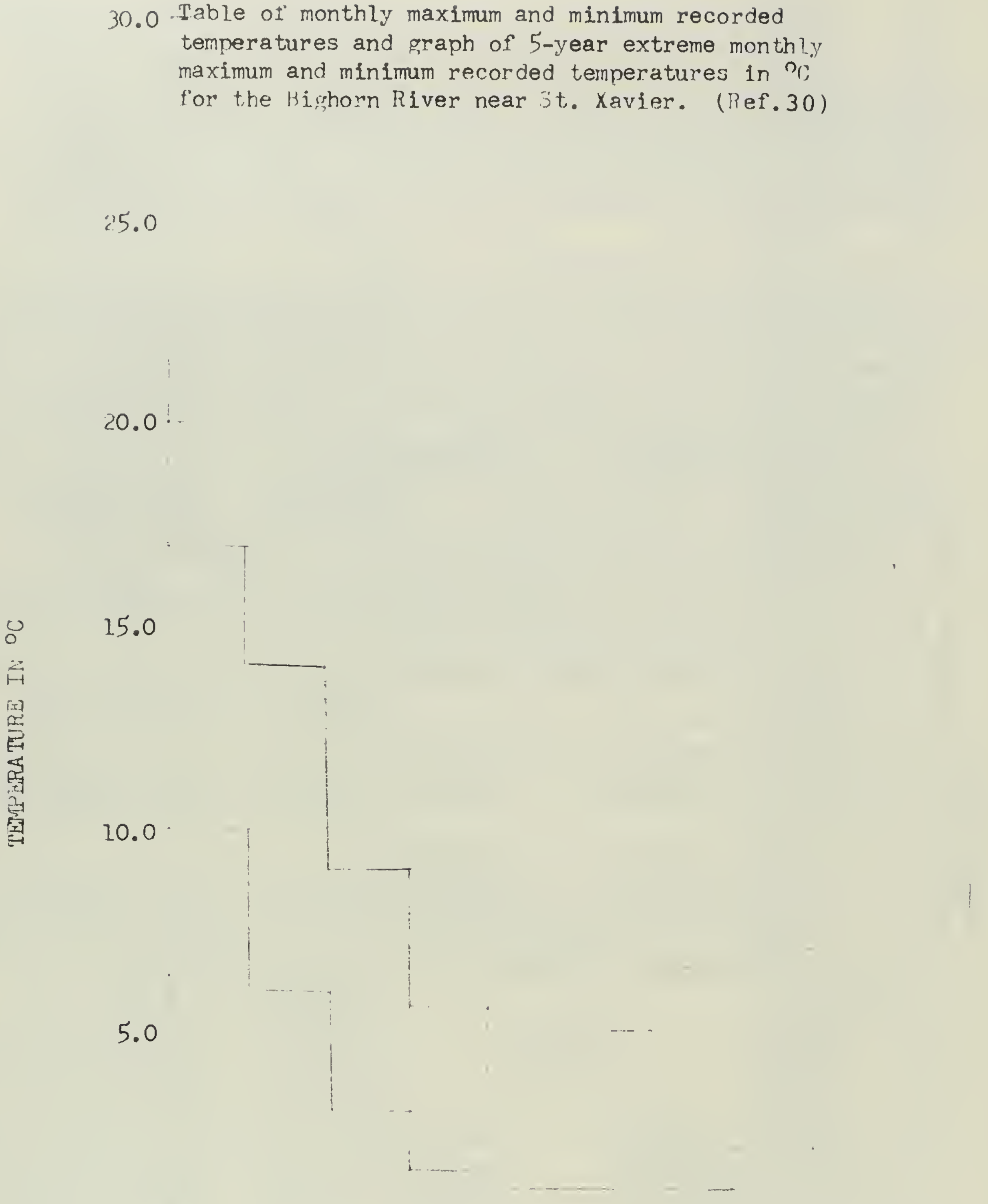
TABLE 14-B

Typical chemical analysis of surface waters in the Bighorn River sub-basin.

Sampling Site Designation	Sampling Site Location*	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25°	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness CaCO3 (mg/l)	Bicarbonate HCO3 (mg/l)	Carbonate CO3 (mg/l)	Alkalinity CaCO3 (mg/l)	Sulfate SO4 (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO3 (mg/l)	Phosphate PO4 (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadmium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
Bighorn River Mainstem																																			
near St. Xavier	06S 31E 16BA	6/2/70	3830	5.5	7.9	976	672				88	30	88	4.1		241	0		322	11	.5	.05		.109											
	06S 31E 16BA	6/4/71	8190	9.0	7.9	930	652				80	28	89	3.7		220	0		320	12	.4			.020											
	06S 31E 16BA	6/8/72	6200	8.0	6.6	818	534				69	23	72	3.6		191	0		250	11	.6			.020											
	06S 31E 16BA	12/9/69	3240	7.0	6.1	978	670				80	29	101	4.5		217	0		325	12	.5			.036											
	06S 31E 16BA	12/1/70	2760		7.8	812	563				73	23	79	3.6		192	0		270	12	.5			.030											
	06S 31E 16BA	12/8/71	4460	5.0	7.9	835	519				66	22	73	3.4		185	0		240	10	.3			.000											
	06S 31E 16BA	9/1/70	1700		7.7	664	445				62	20	59	3.5		170	0		200	6.4	.3			.006											
	06S 31E 16BA	9/10/71	2570	17.0	7.7	517	334				43	14	43	2.5		146	0		140	6.2	.6			.010											
	06S 31E 16BA	9/6/72	3170	15.5	7.7	611	394				54	17	49	2.5		149	0		180	6.4	.4			.030											
near Hardin	01S 33E 24AD	3/2/70	4600																333	13															
	01S 33E 24AD	6/2/71	8000						1.2		65	28							320	11															
	01S 33E 24AD	6/12/72	5640						1.5		69	24							250	10															
	01S 33E 24AD	4/6/70	530																440	13															
	01S 33E 24AD	10/2/70	1600						3.3		79	27							310	12															
	01S 33E 24AD	2/2/72	4000						1.4		72	25							260	11															
	01S 33E 24AD	8/20/70	1900								66	26								10															
	01S 33E 24AD	9/14/71	2400						1.8		47	15							160	6.2															
	01S 33E 24AD	8/21/72	2860						2.0		57	17	51						190	7.3	.4														
at Bighorn	05N 34E 33AA	3/5/69	5030		7.9	914					80	27	83	4.2		219	0		295	11	.5	1.9		.070											
	05N 34E 33AA	6/15/71	9160	16.0	8.0	926	590				75	28	90	3.4		213	0		270	9.8															
	05N 34E 33AA	4/14/72	7170	5.0	8.1	871	573				72	25	76	4.2		207	0		270	12	.4			.010											
	05N 34E 33AA	12/5/68	4230		8.0	900					73	26	84	3.6		212	0		288	13	.4	1.6		.040											
	05N 34E 33AA	1/25/71	3930	1.0	8.0	740	530				70	24	69	3.9		191	0		250	8.1	.4			.120											
	05N 34E 33AA	12/6/71	3660	2.0	8.2	859	541				70	25	76	3.5		197	0		250	10	.4			.020											
	05N 34E 33AA	9/8/69	3750		7.9	866					70	24	84	4.1		188	0		284	9.4	.4	2.0		.070											
	05N 34E 33AA	9/8/71	3030	18.0	7.6	609	402				50	18	52	3.0		160	0		180	6.9	.8			.020											
	05N 34E 33AA	8/7/72	3230	21.0	7.9	673	433				57	20	58	3.0		163	0		200	6.2	.3			.030											
near Hardin	01S 34E 19BE	7/4/73	6000E	13.0		838	622	9.1	1.7	75	58	26	83		251	202	0	166	240	11.8	.33	.28	<.01	.25			<.01	<.01	<.01	<.01			2.3	8	
	02S 33E 21BC	2/15/74	4230	13.0	8.11	914	701	12.0	1.1	10	75	29	83		309	191	6	167	305	10.6		1.0	0.0	.19	.07	0.01	<.01	<.01	<.01		0.007		2.1	2	10.5
	01S 34E 19BA	3/6/74	4820	2.8	8.16	930	708	12.6	2.5	12	78	28	82		311	205	0	168	303	10.5		.93	0.11	.24		<.01	<.01	<.01	<.01	<.01	<.001	<.01	2.0	4	14.8
	02S 33E 21BC	5/16/74	4090	4.5	8.08	982	750	12.4	2.4	26	87	33	83		355	204	12	187	317	13.2		.22	<.03	.16	.01	<.01	<.01	<.001		<.001	<.001	<.01	1.9	4	8.0
at Bighorn	05N 34E 33AA	7/11/73	3700E	18.5		912	605	7.8	3.6	80	60	24	76		249	195	0	160	239	10.2	.31	.22	0.04	.07			0.04	<.01	<.01	<.01			2.1	11	
	05N 34E 33BC	1/22/74	3480	0.5	7.81	860	639	12.5	5.1	170	82	16	75		271	191	0	157	264	9.0		1.4	0.20	1.1	.04	<.01	<.01	<.01			0.003		2.0	30	113
	05N 34E 34BC	2/16/74	4640	4.0	8.13	982	749	12.0	2.5	70	74	32	97		314	222	7	194	307	9.0		1.1	0.01	.58	.07	0.01	0.01	<.01			0.007		2.4	16	40.0
	05N 34E 34BC	4/25/74	6660	9.9	8.30	994	768	10.5	1.6	10	77	36	90		340	240	0	197	314	11.2		.44	0.04	1.0	.05	0.01	<.01	<.001			<.001		2.1	23	65.0
	05N 34E 34BC	5/16/74	5060	7.9	8.42	954	710	11.7	2.0	25	83	30	79		332	212	7	186	285	13.0		.26	0.04	.75	.03	<.01	<.01	<.001		<.001	<.001	<.01	1.9	16	39.2
Tributaries																																			
Crooked Creek	09S 27E 34AA	3/20/74	0.5	6.5		2300	2162				483	84	21	18	1552	148	0	121	1392	15.0	1.2	0.0											0.2		
	09S 27E 34AA	5/30/74	24.5	9.8	8.30	433	361				59	19.5	53.9		228	234	4	198	39	0.7		.27	0.04	4.5	.25	0.03	<.01	<.001		<.001			0.1		
Soap Creek	05S 32E 29AB	12/20/73	11.6	0.0	8.23	1500		13.2	3.2	4													0.18			0.01	<.01	<.01	<.01					8	22.8
	05S 32E 29AB	3/31/74	15.0	3.0	8.19	1021	822	10.5	1.6		117	42	56		467	257	8	224	334	7.0	.54	.13	0.11	2.5	.13	0.01	<.01			<.01	<.001		1.1	51	178
	05S 32E 29AB	5/1/74	138	15.1	8.31	849	690	9.9	2.5	610	84	44	43		391	285	5	241	227	2.3		.18	0.12	3.9	.22	0.02	<.01	<.001			<.001		0.9	80	341
Rotten Grass Creek	05S 33E 17DA	11/19/73		0.5	7.75	2020	1227	12.5	3.1	20	160	66	97		672	269	0	220	628	6.0		.27	0.45	.74		<.01	<.01	<.01	<.01	<.01			1.6	19	
	05S 33E 17DA	12/20/73	18.0	0.0	8.42	1642		13.1	4.1	1980														.35		<.01	<.01	<.01	<.01					10	25.0
	05S 33E 17DA	2/15/74	22.3	0.3	7.87	1536	1318	12.2	0.8	20	150	83	106		715	314	0	257	656	6.0		3.5	0.73	2.3		0.02	<.01	<.01	<.01		<.001		1.7	52	138
	05S 33E 17DA	4/3/74	17.5	5.0	8.27	1533	1247	10.9	2.9	84	134	67	124		610	300	0	246	614	7.0	.38	.66	0.11	3.6	.19	0.03	<.01	<.01		<.01	<.001		2.2	77	228
	05S 33E 17DA	5/1/74	112	11.6	8.19	843	726	10.3	2.5	920	83	38	65		362	254	0	208	283	3.4		.54	0.08	9.5	.50	0.07	0.01	<.001			<.001		1.5	90	996
Tullock Creek E of Hardin	01N 35E 36DD	1/31/74		0.0		1226	968	8.0	4.9	5	34	39	185		245	382	0	313	323	4.0		1.4	0.30	1.0	.08	0.01	<.01	<.01	<.01	<.01		0.01	5.1	35	
	01N 35E 36DD	3/6/74	24.2	0.0	8.05	1184	943	11.6	4.9	0	32	43	170		256	421	4	351	267	4.1		2.3	0.11	2.4		0.01	0.01		<.01	<.01	<.001	<.01	4.6	44	118
	01N 35E 36DD	6/11/74	25.5	17.2	8.48	1270	1027	8.5	4.4		41	62	184		359	454	51	469	230	4.5		.09	0.06	.78	.04	0.01	0.01	<.001			<.001			14	28.0
Tullock Creek near Bighorn	04N 34E 02AC	1/31/74	22	0.0	7.95	942	716	8.9	3.8	11	33	28	132		197	258	0	212					0.30	1.4	.05	0.01	0.01	<.01	<.01	<.01		<.01	4.1	31	50.0
	04N 34E 02AC	2/16/74	30.1	0.2	7.91	911	1005	10.7	3.4	0	37	37	200		245	412	5	346	312	0.4		1.5	0.14	1.4	.07	0.01	<.01	<.01			<.001		5.6	48	88.0
	04N 34E 02AC	4/17/74	7.8	11.5	8.41	1990	1618	9.8	3.1	34	57	56	339		374	528	16	459	612	10.0	.46	.04	0.03	1.6	.15	0.01	0.01	<.001		0.007			7.6	37	76.0
	04N 34E 02AC	6/11/74	36.8	17.1	8.31	2422	1971	7.7	5.8		77	62	45[illegible]		405	572	72	589	735	13.5		.26	0.09	1.4	.53	0.02	<.01	<.001		0.001	<.001	0.02	9.7	245	882
Beauvais Creek near St. Xavier	04S 30E 15	5/5/70	125	20.0	8.1	930	655		1.6		64	23	93	6.5		201	0		330	5.4	.4		0.18	.149	.03	.013	0	0.024	0	0		0			1500
	04S 30E 15	5/3/71	50	19.5	8.3	1010	659	9.8	2.8		140	35	13	3.1		242			330	2.7	0.0			.040	.07	.010	.006	0	0			0			321
	04S 30E 15	3/16/72	68	10.5	8.5	782	533	9.8	1.6		90	24	51	3.3		222	0		240	2.9	.4			.020	.08	.030	.020	0.003	.014			0			308
	05S 30E 15	2/11/69	3.6	0.0	8.1	1500		11.2	3.3		230	47	66	3.2		218	0		712	3.4	.5	1.0	0.21	.270											
	05S 30E 15	12/11/69	1.9	0.0	8.2	1900	1620	11.8	1.1		330	68	67	3.2		303	0		985	3.2	.5		0.02	.032											138
	05S 30E 15	12/9/71	1.5	0.0	7.4	1530	1190	12.4	0.9		240	54	45	2.6		263	0		700	2.6	.5			0	.25										300
	05S 30E 15	8/4/69	7.1	22	8.2	1300		7.2	1.8		198	46	37	3.4		192	0		600	3.2	.5	0.0	0.07	.010											
	05S 30E 15	8/18/70	5.0	19.5	7.8	1370	1140	7.8	0.7		250	50	24	3.2		162	0		720	2.4	.2		0.46	.020	.01										32
	05S 30E 15	8/21/72	7.9	15.5	8.1	1460	1110	8.2	1.7		230	46	42	4.9		206	0		670	2.1	.6			.110	.02										500

* See Appendix II

FIGURE 30
Table of monthly maximum and minimum recorded temperatures and graph of 5-year extreme monthly maximum and minimum recorded temperatures in °C for the Bighorn River near St. Xavier. (Ref.30)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1968	17	14	9	5	3	3	5	6	13	15	16	17
	14	8	5	3	1	1	2	3	6	12	14	14
1969	16	12	9	4	3	2	4	5	14	11	14	16
	12	8	3	2	2	1	1	2	3	4	9	13
1970	15.5	11.5	9.0	5.5	3.5	5.0	6.5	5.0	5.5	16.5	14.5	15.0
	10.0	8.5	5.5	3.0	1.5	1.5	3.0	3.5	4.0	5.0	11.0	12.0
1971	14.0	10.5	8.5	5.0	3.0	2.0	3.5	7.0	13.0	16.5	18.0	17.0
	10.0	8.0	5.0	2.0	1.0	1.0	1.5	3.0	6.5	13.0	16.0	14.5
1972	14.5	11.5	6.5	4.5	1.5	3.0	3.5	6.5	----	15.5	16.5	17.0
	11.0	6.0	4.5	1.5	1.0	1.0	2.0	3.5	6.0	13.0	15.0	15.5

FIGURE 31

Table of monthly maximum and minimum recorded temperatures and graph of 5-year extreme monthly maximum and minimum recorded temperatures in °C for the Bighorn River at Bighorn. (Ref. 30)

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1968	17	10	6	5	4	9	10	14	18	23	22	18
	8	0	0	0	0	1	0	7	9	14	15	13
1969	15	10	5	1	0	5	14	18	17	19	20	19
	8	4	0	0	0	0	1	8	10	13	16	14
1970	15.0	12.0	8.0	5.5	6.5	7.5	10.0	15.5	17.5	20.5	24.0	18.5
	6.0	4.0	0.0	0.0	0.0	0.0	3.0	6.0	11.0	11.5	17.0	9.0
1971	15.0	10.5	7.5	5.0	5.0	6.5	10.0	13.5	19.0	21.0	23.0	19.5
	6.0	0.0	0.0	0.0	0.0	0.0	3.5	7.0	10.5	15.0	17.0	10.5
1972	14.0	10.0	5.0	3.0	2.5	9.5	9.5	16.5	18.0	21.5	22.0	18.0
	4.5	5.5	0.0	0.0	0.0	0.0	3.0	5.5	12.0	13.5	18.0	10.0

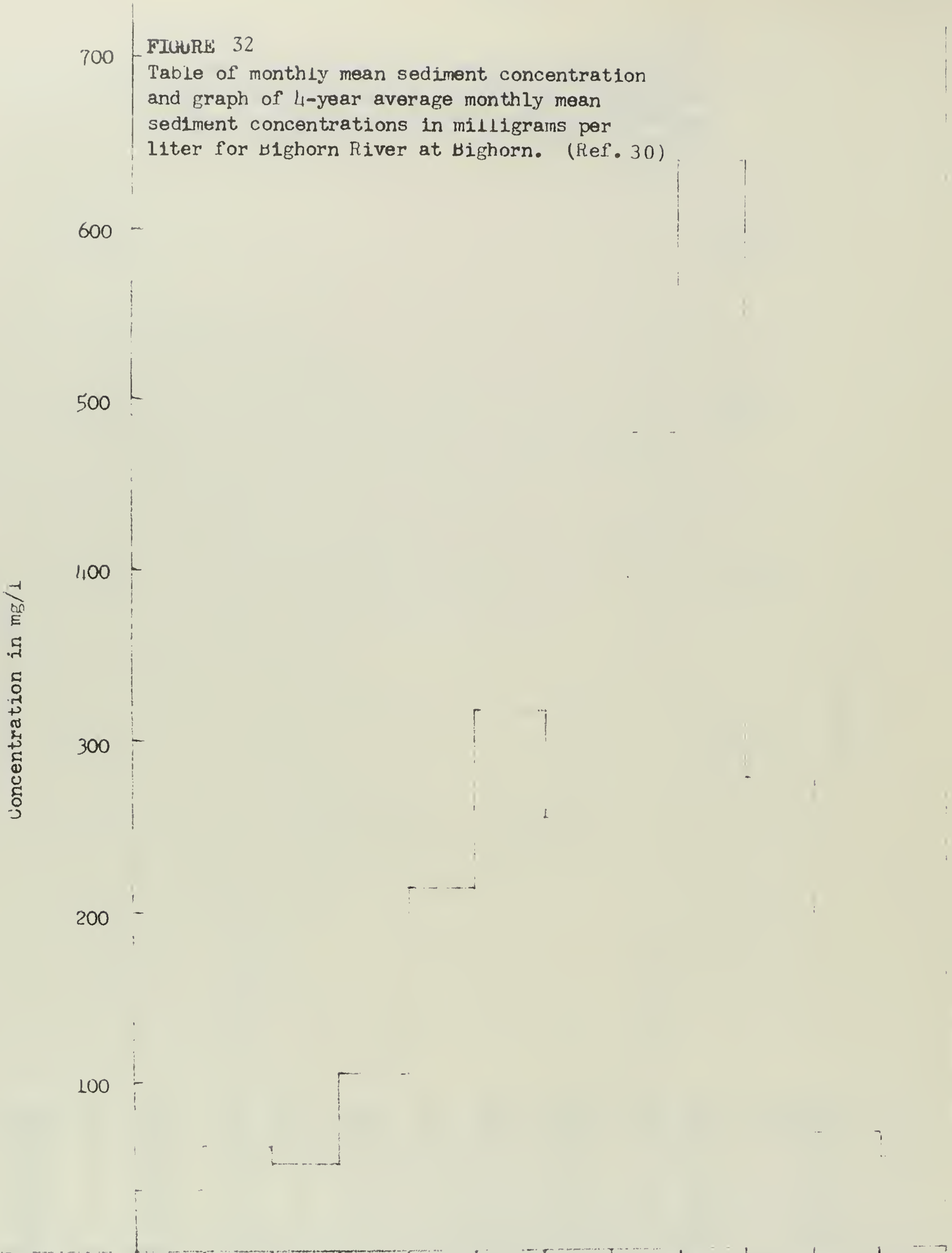


FIGURE 32
Table of monthly mean sediment concentration and graph of 4-year average monthly mean sediment concentrations in milligrams per liter for Bighorn River at Bighorn. (Ref. 30)

Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1968	42	128	98	142	162	200	54	251	976	180	85	60
1969	30	72	27	85	291	485	191	227	724	497	70	57
1970	37	18	20	83	71	309	516	1219	598	351	66	42
1971	38	30	58	109	330	279	265	221	267	89	48	54
Average	37	62	52	105	214	318	256	480	641	279	69	53

ROSEBUD CREEK SUB-BASIN

The Montana State Department of Health and Environmental Sciences has classified waters in this sub-basin as B-D3. Rosebud Creek is the major stream in this sub-basin. The Water Quality Bureau established six sampling sites on Rosebud Creek to obtain data for this study. These were south of Kirby, at Busby, south of Colstrip, east of Colstrip, south of Rosebud, and near Rosebud. Tributaries to Rosebud Creek sampled by the Water Quality Bureau were Indian Creek, Davis Creek, Muddy Creek, and Lame Deer Creek. Only one sampling site was established on each tributary stream near its confluence with Rosebud Creek (Plate I, Figure 1).

Table 15 shows typical chemical analysis of surface waters in the Rosebud Creek sub-basin. Specific conductance increases from the upstream to the lower stations. For samples collected on the same day a much higher value in flow was measured at the Busby station than expected from that measured south of Kirby. There may be significant amounts of groundwater entering the stream in this reach which would account for the increase in specific conductance. Davis Creek enters Rosebud Creek in this reach near Busby but its flow is too small to account for all of the increase in specific conductance.

The increase in concentration of the common ions in moving downstream along Rosebud Creek are not very distinct for any particular ion. There is a possible increase in sodium, magnesium, sulfate, and chloride. One interesting feature of many samples collected on Rosebud Creek is the higher milliequivalence per liter of magnesium than of calcium. This is also true for all of the samples collected on the tributaries with the exception of Indian Creek. Indian Creek is the only tributary sampled whose general water quality is better than that of Rosebud Creek. Indian Creek is in the upper drainage of Rosebud Creek. The remaining tributaries sampled have specific conductances significantly higher than Rosebud Creek. The associated higher concentrations of common ions are magnesium, sodium, bicarbonate, sulfate, and chloride.

There is a definite increase in sediment concentrations from the upper station on Rosebud Creek to the lower station. Loads for various parameters are tabulated in tons/day for all of the stations sampled in this sub-basin. These are summarized below. Except for Lame Deer Creek and Indian Creek, all of the other samples were collected on April 30, 1974. The samples from Lame Deer Creek and Indian Creek that were used to determine their loads were collected on March 4 and May 1, 1974, respectively.

Load in tons/day

Stream & Site	Mg	Na	HCO_3	SO_4	Cl	TSS	TDS
Indian Creek S of Kirby	0.9	0.3	7.7	1.1	0.04	1.6	11
Rosebud Creek S of Kirby	3.3	1.0	23	7.2	0.10	1.7	39
Davis Creek near Busby	0.7	0.8	3.4	2.5	0.04	0.1	8.0
Rosebud Creek near Busby	10	4.8	74	20	0.50	44	122
Muddy Creek E of Busby	0.8	0.7	3.7	2.8	0.02	0.02	8.6
Lame Deer Creek near Lame Deer	0.5	0.4	3.0	1.1	0.05	0.06	5.6
Rosebud Creek S of Colstrip	16	11	89	45	0.75	122	181
Rosebud Creek E of Colstrip	14	9.7	76	42	0.68	113	158
Rosebud Creek S of Rosebud	16	13	87	51	1.0	118	185
Rosebud Creek near Rosebud	14	10	70	43	0.44	91	150

TONGUE RIVER SUB-BASIN

The Tongue River drainage from the Montana/Wyoming border to but excluding Prairie Dog Coulee has been designated B-D_2 by the Montana State Department of Health and Environmental Sciences. The remainder of the sub-basin is designated as B-D_3 (Appendix B).

The USGS maintains water quality stations on the Tongue River at the state line and at Miles City. The USGS station on the Tongue River Irrigation Reservoir discharge is now discontinued. Several new water quality stations on the Tongue River are expected to be established in the near future by the USGS. The Water Quality Bureau established sampling sites on the Tongue River upstream from the Montana/Wyoming state line above the reservoir, on the Tongue River Reservoir, below the reservoir discharge near Birney, and at Ashland. Several samples were also collected by the Water Quality Bureau at the USGS stations.

There are three major tributaries to the Tongue River--Hanging Woman, Otter, and Pumpkin Creeks. The USGS maintains water quality stations on Hanging Woman Creek and Otter Creek

Table 1[illegible]
Typical chemical analysis of water in the Rosebud Creek sub-basin--
Rosebud Creek and tributaries.

Sampling Site Designation	Sampling Site Location *	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25° C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness CaCO$_3$ (mg/l)	Bicarbonate HCO$_3$ (mg/l)	Carbonate CO$_3$ (mg/l)	Alkalinity CaCO$_3$ (mg/l)	Sulfate SO$_4$ (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO$_3$ (mg/l)	Phosphate PO$_4$ (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
Rosebud Creek Mainstem																																			
S of Kirby	06S 39E 29BA	1/17/74	5.7	0.0	8.31	762	613	11.3	4.3	41	88	41	11		390	384	0	315	85	1.5	.50	0.94	0.21	0.47		<.01	<.01	<.01	<.01	.01			0.2	10	9.0
	06S 39E 29BA	2/28/74	11.2	0.0	8.09	880	749	12.0	3.2	3000	72	68	23		459	435	0	357	150	1.2		0.23	0.11	0.53		0.01	<.01	<.01	<.01	.01	<.001	<.01	0.5	9	18.0
	06S 39E 29BA	4/17/74	27.0	11.0	8.48			13.3		5																								11	24.0
	06S 39E 29BA	4/30/74	22.7	14.0	8.33	760	641	9.2	1.7	30	72	54	17		403	367	11	319	118	1.6		0.04	0.03	0.44	0.08	0.01	<.01	<.001			<.001	<.01	0.4	10	28.0
at Busby	04S 39E 06AP	7/4/73		18.0		785	672	7.9	3.1	170	58	57	31		381	431	4	365	90	0.3	.51	0.78	0.02				<.01	<.01	<.01	.01			0.7	51	
	04S 39E 06AB	1/17/74	75.6	0.0	7.63	485	363	11.6	11.4	480	47	194	18		197	[illegible]	0	175	61	2.5	.18	1.1	0.53	0.30		<.01	<.01	<.01	<.01	.01			0.6	11	25.9
	04S 39E 06AB	2/28/74	18.0	0.0	8.18	997	851	12.9	4.0	2	69	73	46		473	472	0	387	189	1.5		0.22	0.07	0.35		0.01	0.01	<.01	<.01	.01	<.001	<.01	0.9	7	[illegible]
	04S 39E 06AB	4/30/74	63.8	11.8	8.34	805	705	9.8	3.0	30	66	60	28		412	429	0	352	118	3.1		0.12	0.09	3.2	0.21	0.01	<.01	<.001			<.001		0.6	78	254
S of Colstrip	01S 42E 08DB	12/13/73	20.5	2.2	8.31	1320		12.8	2.9	2														0.32		0.01	<.01	<.01	<.01					10	20.8
	01S 42E 08DB	1/17/74		0.0	7.92	1152	937	11.7	9.3	100	104	62	67		515	[illegible]	0	305	327	3.0	.34	1.3	0.26	1.0		<.01	<.01	<.01	<.01	.01			1.3	8	8.0
	01S 42E 08DB	1/24/74	100.2	0.0	7.73	699	523	11.8	8.1	20	58	34	31		286	254	0	209	140	3.5		1.5	0.29	0.56	0.02	<.01	<.01	<.01			0.001		0.8	12	25.0
	01S 42E 08DB	3/1/74	24.5	0.0	8.21	1298	1081	13.0	3.8	21	80	91	84		574	486	0	398	337	2.8		0.13	0.05	0.39		0.01	0.01	<.01	<.01	.01	<.001		1.5	8	13.5
	01S 42E 08DB	4/30/74	81.9	13.3	8.36	972	815	9.2	3.1	20	69	74	49		476	406	17	356	202	3.4		0.16	0.13	8.2	0.33	0.04	0.01	<.001			<.001	0.02	1.0	180	550
E of Colstrip	03N 43E 05DC	3/1/74	27.6	0.0	8.28	1257	1038	12.6	4.1	4	75	88	86		549	431	4	359	350	2.9		0.31	0.06	0.78		0.01	0.01	<.01	<.01	.01	<.001		1.6	17	28.0
	03N 43E 05DC	4/30/74	70.2	13.5	8.35	1016	834	9.2	3.1	40	68	74	51		474	400	14	352	222	3.6		0.36	0.13	8.8	0.38	0.06	0.01	<.001			<.001		1.0	190	597
S of Rosebud	05N 42E 08DC	12/14/73	36.9	1.0	8.32	1620		12.8	2.7	16														0.34		<.01	<.01	<.01	0.01					14	43.3
	05N 42E 08DC	3/1/74	30.6	0.9	8.00	1191	996	12.5	4.3	3	66	81	88		459	417	0	342	338	4.8		0.58	0.08	1.9		0.02	0.01	<.01	<.01	.01	<.001		1.7	43	112
	05N 42E 08DC	4/30/74	77.2	12.8	8.29	1036	885	9.8	3.2	90	66	77	60		484	419	14	368	243	4.6		0.26	0.13	7.8	0.45	0.05	0.01	<.001			<.001		1.2	210	564
	05N 42E 08DC	6/20/74	58.8	22.4	8.42	1047	870	8.3			66	75	[illegible]		472	420	4	351	241	4.0		0.38	0.12	6.8	0.39	0.05	0.01	<.001		.001	<.001	0.01	1.2	190	402
near Rosebud	06N 42E 16DC	10/24/73	4E			1580	1322				135	72	[illegible]		634	[illegible]	[illegible]	429	453	8.0	.56	1.5	0.29										2.4	43	
	06N 42F 16DC	1/21/74	180.4	0.0	7.68	584	419	12.1	11.6	240	51	13.3	47		183	163	0	134	137	5.8		0.63	0.49	2.5	0.05	<.01	0.01	<.01		.01			1.5	82	200
	06N 42E 16DC	3/1/74	36.5	1.1	7.90	1162	943	12.6	4.6	150	63	76	92		468	[illegible]		326	310	4.2		0.47	0.83	2.5		0.01	0.01	<.01	<.01	.01	<.001	0 01	1.9	52	130
	06N 42E 16DC	4/17/74	74.0	11.0	8.42	1239	1035	10.7	3.4	34	58	95	90		535	[illegible]		361	352	5.8													1.7	>100	243
	06N 42E 16DC	4/30/74	63.0	14.2	8.39	1076	882	9.8	3.3	170	64	80	60		489	[illegible]		358	251	2.6		0.22	0.11	7.3	0.52	0.06	0.01				<.001	0.02	1.2	220	530
Tributaries																																			
Indian Creek	06S 39E 29BA	5/1/74	8.7	10.7	8.29	577	485	10.4	3.2	0	60	37	11		302	[illegible]		269	47	1.6		0.14	0.08	<.01	0.04	0.01	<.01	<.001			<.001		0.3	11	69.0
Davis Creek	04N 38E 11DB	2/28/74	2.6	0.0	8.23	1446	1145	12.9	4.5	12	74	87	112		544	[illegible]	[illegible]	452	317	3.8		0.22	0.03	0.24		0.02	0.01	<.01	<.01	.01	<.001		2.1	2	6.0
	04N 38E 11DB	4/30/74	2.0	14.0	8.23	1685	1477	10.7	2.4	10	67	129	150		696	[illegible]	[illegible]	551	462	7.1		0.0	0.13	0.53	0.20	0.01	<.01	<.001			<.001		2.5	9	21.0
Muddy Creek	02S 40E 35CC	4/30/74	2.9	16.3	8.50	1317	1095	11.2	1.5	10	54	108	95		[illegible]	[illegible]	[illegible]	[illegible]	357	2.8		0.0	<.03	0.38	0.05	<.01	<.01	<.001			<.001		1.7	7	24.0
Lame Deer Creek	02S 41E 28DB	1/30/74	3.0	0.00	7.98	1040	876	9.5	2.5	28	65	74	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	163	0.2		1.1	0.11	0.05	0.02	<.01	<.01	<.01	<.01	.01		<.01	1.1	9	10.0
	02S 41E 28DB	[illegible]/30/74	3.0	0.00	8.00	1126	947	11.8	7.5	550	63	82	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.1		2.9	0.40	1.1	0.14	<.01	<.01	<.01	<.01	.01		.01	[illegible]	22	58.0
	02S 41E 28DB	4/4/74	2.0	4.5	8.40	1181	1034	13.5	4.0	130	70	86	[illegible]		530	[illegible]		[illegible]	212	6.6	.98	0.13	0.90	0.25	0.05	<.01	<.01	<.02		.01	<.001		1.6	6	11.0

* See Appendix II

near their confluences with the Tongue River. These stations were established only recently and no data has been published for the sites. As a result, the Water Quality Bureau established sampling stations on both of these creeks at the current USGS sites in addition to upstream stations on each stream. A sampling station on Pumpkin Creek was established by the Water Quality Bureau at the USGS stream flow station near the creek's mouth near Miles City. The Bureau also established an upstream site on Pumpkin Creek near Volborg.

A few minor streams were sampled in this sub-basin in addition to those noted above. They were Youngs Creek near Decker, Squirrel Creek at Decker, Deer Creek near Decker, Stroud Creek near Otter, Logging Creek near Ashland, Cow Creek near Ft. Howe, and Little Pumpkin Creek near Volborg (Plate I, Figure 1).

Unlike the reservoir on the Bighorn River (Yellowtail Reservoir), no extensive water quality study has been made on the Tongue River Irrigation Reservoir. A water quality and ecological study is planned for this reservoir as a part of the EPA's National Eutrophication Study.

Table 16 lists the typical chemical analysis of the surface waters in the Tongue River sub-basin. With the exception of samples collected from Logging and Cow Creeks, all samples collected on the tributary streams of the Tongue River, both major and minor, show high specific conductances ranging from 975 to 6570 micromhos/cm at 25°C. Like waters in Rosebud Creek sub-basin, samples on the tributary streams had generally higher milliequivalencies of magnesium than for calcium. Concentrations of the common ions for these samples tended to be quite high. There is a general decrease in the concentrations of the dissolved constituents for each of the major tributaries from their upstream to their downstream station. Sodium and sulfate concentrations are quite high for these creeks even at runoff periods relative to the Tongue River. Flows of both the major and minor tributaries are usually at least two orders of magnitude less than that of the Tongue River. As a result, these streams are not likely to produce a significant load in an independent sense but collectively they probably degrade waters in the Tongue River. This may be especially evident during the high flow periods of the tributary streams which do not correspond to a high flow period for the Tongue River (early spring for the former versus June for the latter).

Specific conductance values for the Tongue River at the state line vary with flow from around 300 to 1000 umhos/cm at 25°C. The values of specific conductance for the Tongue River at Miles City seem to vary from around 500 at high flows to 1100 at low flows. This would indicate a slight increase in the concentration of dissolved constituents. This slight increase is due to increased concentrations of sodium and sulfate at low flow periods. For the samples collected on the Tongue River at relatively low flows, the millequivalents of magnesium were generally equal to or greater than that for calcium.

Loads for the three major tributaries have been determined. The data used was that collected at their respective confluences during a relatively high flow. As was mentioned in the Surface Water Resources section, there is a relatively high flow period in early spring on the Tongue River which is probably due to above average runoff in these tributary streams. The loads of selected parameters for these major tributaries are tabulated below along with loads for a sample taken in early spring on the Tongue River below the reservoir.

Load in tons/day

Stream & Site	Mg	Na	HCO_3	SO_4	TSS	TDS
Tongue River below Reservoir	28	33	140	158	3.5	410
Hanging Woman Creek at Birney	2.1	5.5	10	18	1.0	37
Otter Creek near Otter	2.7	7.1	10	21	0.3	45
Pumpkin Creek nr Miles City	4.5	55	5.3	108	120	220

Figures 33 and 34 include tables of the monthly maximum and minimum water temperatures and graphs of five-year extreme monthly maximum and minimum water temperatures for the Tongue River at the state line and at Miles City. Of interest is the extreme monthly temperatures for January of 0°C for the Tongue River at Miles City.

YELLOWSTONE RIVER SUB-BASIN--BIGHORN RIVER TO TONGUE RIVER

This entire sub-basin has been designated as B-D3 by the State Department of Health and Environmental Sciences (Appendix B). The USGS has maintained a water quality station at Miles City on the Yellowstone River. Several new stations are expected to be installed by the USGS in the next year on the Yellowstone in response to coal developments at Colstrip. The Water Quality Bureau (WQB) sampled the Yellowstone River at Myers, Forsyth, Rosebud, and Miles City.

Table 16

Typical chemical analysis of surface waters in the Tongue River sub-basin.

Sampling Site Designation	Sampling Site Location *	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25° C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness CaCO$_3$ (mg/l)	Bicarbonate HCO$_3$ (mg/l)	Carbonate CO$_3$ (mg/l)	Alkalinity CaCO$_3$ (mg/l)	Sulfate SO$_4$ (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO$_3$ (mg/l)	Phosphate PO$_4$ (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
<u>Tongue River Mainstem</u>																																			
at state line	09S 40E 33AB	3/18/69	2000		7.0	550					43	26	21	11.		158	0		127	4.9	.4	3.7													
	09S 40E 33AB	6/3/70	2580	16.0	8.0	3[illegible]4	188				[illegible]	14	10	1.4		128	[illegible]		5.6	1.0	.2	0.5		.180											
	09S 40E 33AB	5/24/7[illegible]	1640	16.0	7.9	[illegible]	[illegible]				[illegible]	1	[illegible]			[illegible]	[illegible]		67	1.8	.2	0.9		.150											
	09S 40E 33AB	2/5/69	[illegible]		8.3	[illegible]	[illegible]				[illegible]	4	34	[illegible]		279	[illegible]		208	3.2	.4	2.0													
	09S 40E 33AB	12/10/7[illegible]	[illegible]	0.0	8.1	[illegible]					[illegible]	4	[illegible]	[illegible]		[illegible]	0		[illegible]	4.6	.3	1.1		.120											
	09S 40E 33AB	[illegible]	[illegible]	0.0	[illegible]	[illegible]	[illegible]					[illegible]		[illegible]		[illegible]	0		200	5.0	.3	1.8		0.20											
	09S 40E 33AB	[illegible]	[illegible]		8.1	[illegible]	[illegible]				[illegible]	[illegible]	5	4.4		[illegible]	0		293	5.6	.5	0.1													
	09S 40E 33AB	8/25/71	77	16.0	8.1	[illegible]	73[illegible]				91	61	61	6.9		321	0		340	5.4	.4	0.6		.100											
	09S 40E 33AB	8/23/72	217	18.5	8.3	816	538				76	47	39	4.2		364	0		210	4.0	.4	0.3		.110									0.9		
at Miles City	07N 47E 23D	6/4/70	3360	20	7.9	[illegible]	[illegible]				49	2[illegible]	25	3.3		[illegible]	0		114	0.8	.2	0.08		.046											
	07N 47E 23D	6/9/71	1840	19.0	7.6	[illegible]	[illegible]				[illegible]	20	33	3.0		[illegible]	0		110	5.4	.4			0.80											
	07N 47E 23D	3/9/72	2800	1.0	7.2	463	[illegible]				32	17	39	5.2		[illegible]	0		120	2.8	.2	0.16		.020									1.4		
	07N 47E 23D	1/8/70	150	0.0	8.0	[illegible]	[illegible]				85	70	87	6.3		[illegible]9	0		337	4.2	.4	0.05		.118											
	07N 47E 23D	1/12/71	172	0.0	8.0	966	690				91	54	72	5.4		369	0		280	4.5	.3			.140											
	07N 47E 23D	1/11/72	128	0.0	7.8	1120	755				80	58	88	4.8		363	0		330	6.3	.4			0.20									1.8		
	07N 47E 23D	8/4/70	243		8.2	580	366				45	26	40	3.5		213	0		134	2.6	.4			.149											
	07N 47E 23D	8/4/71	69	22.0	8.0	881	562				57	37	79	4.5		287	0		230	3.3	.7			0.20											
	07N 47E 23D	8/2/72	233	22.5	8.1	787	495				54	33	65	4.6		259	0		200	3.0	.3			0.20											
near Sheridan, WY	57N 84W 01	3/21/74	215E	3.7	8.31	647	522	13.4	3.5	2	59	39	26		310	267	4	225	125	1.0	.3	0.0	0.17	0.31	0.06	0.01	<.01	<.001	<.01	<.001	<.001		0.6	8	14.0
	57N 84W 01	5/8/74	1150E	11.3	7.83	236	179	10.0	4.3		26	8.7	5.5		102	112	0	92	25	0.5		0.16	0.17	1.2	0.09	0.01	<.01	<.001		<.001	<.001		0.2	28	85.5
near Decker, MT	09S 40E 22D	1/30/74	300	0.0	7.90	878	685	11.2			75	50	36		392	302	0	248	219	1.0		1.6	0.25	0.11	0.05	<.01	<.01	<.01	<.01	<.01		<.01	0.8	6	10.0
	09S 40E 22D	3/21/74	215	4.0	8.36	1061	853	13.3	3.4	2	83	67	59		486	306	5	259	330	2.0	.3	0.0	0.08	0.62	0.10	0.01	<.01	<.001		<.01	<.001		1.2	15	31.0
	09S 40E 22D	5/8/74	1150	13.0	7.90	312	235	9.1	3.2		31	16	6.9		144	128	0	105	53	0.0		0.35	0.15	1.4	0.06	0.01	<.01	<.001		<.001	<.001	<.01	0.3	35	109.5
below Reservoir	06S 42E 27AA	3/21/74	217	3.8	8.33	956	694	13.8	3.7	0	73	47	56		376	240	5	205	270	2.0	.3	0.09	<.03	0.13	0.02	<.01	<.01	<.001		<.01	<.001		1.3	2	6.0
	06S 42E 27AA	5/9/74	860	11.2	8.12	801	650	10.0	3.9		67	45	51		352	254	0	208	230	3.0		0.11	0.03	0.35	0.07	0.02	<.01	<.001		<.001	<.001	<.01	1.2	5	16.4
near Birney	05S 43E 08DD	1/30/74	240	0.0	6.29	910	727	11.7		2	70	53	52		391	299	0	245	242	1.2		0.60	0.0	0.06	0.04	<.01	<.01	<.01	<.01	<.01		<.01	1.1	4	4.0
	05S 43E 08DD	5/9/74	820E	14.8	8.37	792	645	9.4	3.7		65	46	45		352	245	5	209	235	3.5		0.13	0.03	0.47	0.11	<.01	<.01	<.001		<.001	<.001		1.0	9	37.0
at Ashland	03S 44E 10BD	7/3/73	650E	23.5		315	232	8.9	3.2	29	25	14.0	17		120	133	0	109	42	0.8	.12	0.22	<.01	0.11			0.01	<.01	0.02	<.01			0.7	23	
	03S 44E 10BD	1/17/74	230	0.0	8.55	886	703	10.9	3.4	65	73	48	50			298	0		230	3.0	.27	0.54	0.10	2.7		<.01		<.01					1.1	11	33.0
	03S 44E 10BD	3/22/74	270	3.4	8.30	990	797	13.0	3.5	0	76	53	68		410	299	7	256	290	3.5		0.0	<.03	0.22	0.02	0.01	0.01	<.001		<.01	<.001		1.5	3	8.0
	03S 44E 10BD	5/9/74	780E	15.1	8.30	634	667	9.3	3.2		68	48	48		368	256	4	216	240	3.0		0.10	<.03	0.90	0.13	<.01	<.01	<.001		<.001	<.001		1.1	16	62.5
at Brandenburg	01S 44E 16DB	3/22/74	255E	3.0	8.32	1024	791	13.0	3.5	0	70	56	68		404	301	4	253	290	2.0	.3	0.14	<.03	0.30	0.04	<.01	<.01	<.001		<.01	<.001		1.5	4	11.0
	01S 44E 16DB	5/9/74	740E	15.8	8.30	863	690	9.3	3.0		71	47	56		369	261	2	218	250	3.5		0.04	<.03	1.1	0.12	0.01	<.01	<.001		<.001	<.001		1.3	26	78.4
near Garland	03N 47E 06BD	3/22/74	240E	2.5	8.29	1073	773	12.9	4.6	0	46	71	65		408	268	0	220	320	2.0	.4	0.18	0.07	0.41	0.05	0.01	<.01	<.001		<.01	<.001		1.4	8	19.0
	03N 47E 06BD	5/9/74	700E	18.0	8.30	870	694	9.1	4.5		67	50	54		373	268	0	220	250	4.0		0.04	<.03	1.7	0.16	0.01	<.01	<.001		<.001	<.001		1.2	30	104
at Miles City	07N 47E 04DD	7/16/73	300	26.7		572	455	7.6	0.9	45	48	26	38		228	199	2	167	139	1.7	.19	0.24	0.02	0.03		0.03	<.01		<.01	<.01			1.1	23	
	07N 47E 04DD	3/22/74	225	0.0	8.25	1060	857	13.3	3.5	0	71	61	79		427	320	4	268	320	3.0	.3	0.0	<.03	0.50	0.04	<.01	<.01	<.001		<.01	<.001		1.7	12	22.0
	07N 47E 04DD	4/25/74	425	20.3	8.31	950	762	9.1	2.1	8	72	48	68		379	280	0	230	289	4.4		0.0	<.03	0.70	0.11	0.01	<.01	<.001			<.001		1.5	21	58.0
	07N 47E 04DD	5/9/74	670	17.3	8.30	862	687	9.0	3.7		67	46	60		354	266	0	218	245	4.0		0.0	<.03	2.0	0.15	0.02	<.01	<.001			<.001	<.01	1.4	37	121
	07N 47E 04DD	6/10/74	1320	16.0	7.63	42[illegible]	319	8.5	3.2		37	18	22		166	151	0	124	88	1.5		0.89	0.06	5.0	0.30	0.02	<.01	<.001		<.001	<.001	<.01	0.7	184	378
<u>Tributaries</u>																																			
Reservoir	08S 40E 25BB	3/21/74		2.7	7.99	775	601	13.6	5.3	0	65	45	36		346	253	0	207	200	2.0	.3	0.29	0.22	.011	0.02	0.01	0.01	<.001		<.01	<.001		0.8	2	4.0
	08S 40E 25BB	5/8/74		17.2	8.20	475	359	11.8	5.1		42	25	16		208	170	0	139	105	1.5		0.22	0.06	0.35	0.05	0.01	<.01	<.001		<.001	<.001	<.01	0.5	9	16.0
Youngs Creek	57N 84W	5/9/74	5.3	10.5	8.20	975	829	9.4	2.0		76	74	42		494	403	2	334	230	2.0		0.09	0.11	1.9	0.25	0.01	<.01	<.001		<.001	<.001		0.8	36	85.0
Squirrel Creek	09S 40E 29CA	3/21/74	7.8	0.6	7.97	1724	1391	12.1	4.5	76	92	115	138		705	401	0	329	640	4.5		0.0	0.03	3.5	0.48	0.01	0.01	0.001		<.01	<.001		2.3	48	124
Deer Creek	09S 41E 10CC	5/8/74	0.3	20.2	7.98	5610	5299	13.1	4.4		279	312	875		1980	559	8	472	3250	16.5		0.0	<.03	0.50	0.35	0.02	<.01	<.001		<.001	<.001		8.6	8	29.0
Hanging Woman Creek W of Quietus	08S 43E 16DD	1/30/74	4E	0.0	7.77	1357	1066	8.4	7.8	6	62	57	174		210	0	0		556	4.7		1.9	0.70	0.77	0.11	<.01	<.01	<.01	<.01	<.01		<.01	3.8	14	20.0
	08S 43E 16DD	3/21/74	2.1	3.8	8.01	3963	3668	12.3	6.0	260	285	136	620		1270	536	0	439	2080	11.5		0.0	<.03	0.92	0.32	0.01	0.02	<.001		<.01	<.001		7.6	12	20.0
	08S 43E 16DD	5/16/74	0.4	15.0	8.30	4736	4196	10.3	2.9	2	196	230	725		1438	553	15	479	2464	11.8		0.0	0.02	0.80	0.12	<.01	<.01	<.001		<.001	<.001		8.3	16	33.0
Stroud Creek	08S 43E 02AC	5/16/74	0.07	10.5	8.21	2617	2179	18.0	2.3	13	85	126	372		732	603	18	525	966	8.6		0.0	<.03	0.15	0.02	<.01	<.01	<.001		<.001	<.001		6.0	3	8.0
Banging Woman Creek nr Birney	06S 43E 19DD	1/30/74	12E	0.0	7.69	1483	1151	11.4	6.2	70	68	64	170		434	295	0	242	548	3.5		1.52	0.27	1.4	0.14	0.01	<.01	<.01		<.01		0.01	3.6	19	30.0
	06S 43E 19DD	3/21/74	2.9	4.0	8.17	2620	2308	12.5	3.2	0	120	127	371		821	592	0	485	1090	9.0		0.0	<.05	0.48	0.15	0.01	0.02	<.001		<.01	<.001		5.6	4	11.0
	06S 43E 19DD	4/4/74	2.9	4.8	8.16	27[illegible]	2349	11.5	3.2	72	83	160	375		866	604	11	513	1114	1.8	.91	0.0	0.05										5.5	11	19.0
	06S 43E 19DD	5/16/74	2.8	15.5	8.32	28[illegible]4	2346	11.8	3.5	92	110	136	390		835	585	0	480	1115	10.6		0.0	<.03	1.4	0.17	0.01	<.01	<.001		<.001	<.001		5.9	24	70.0

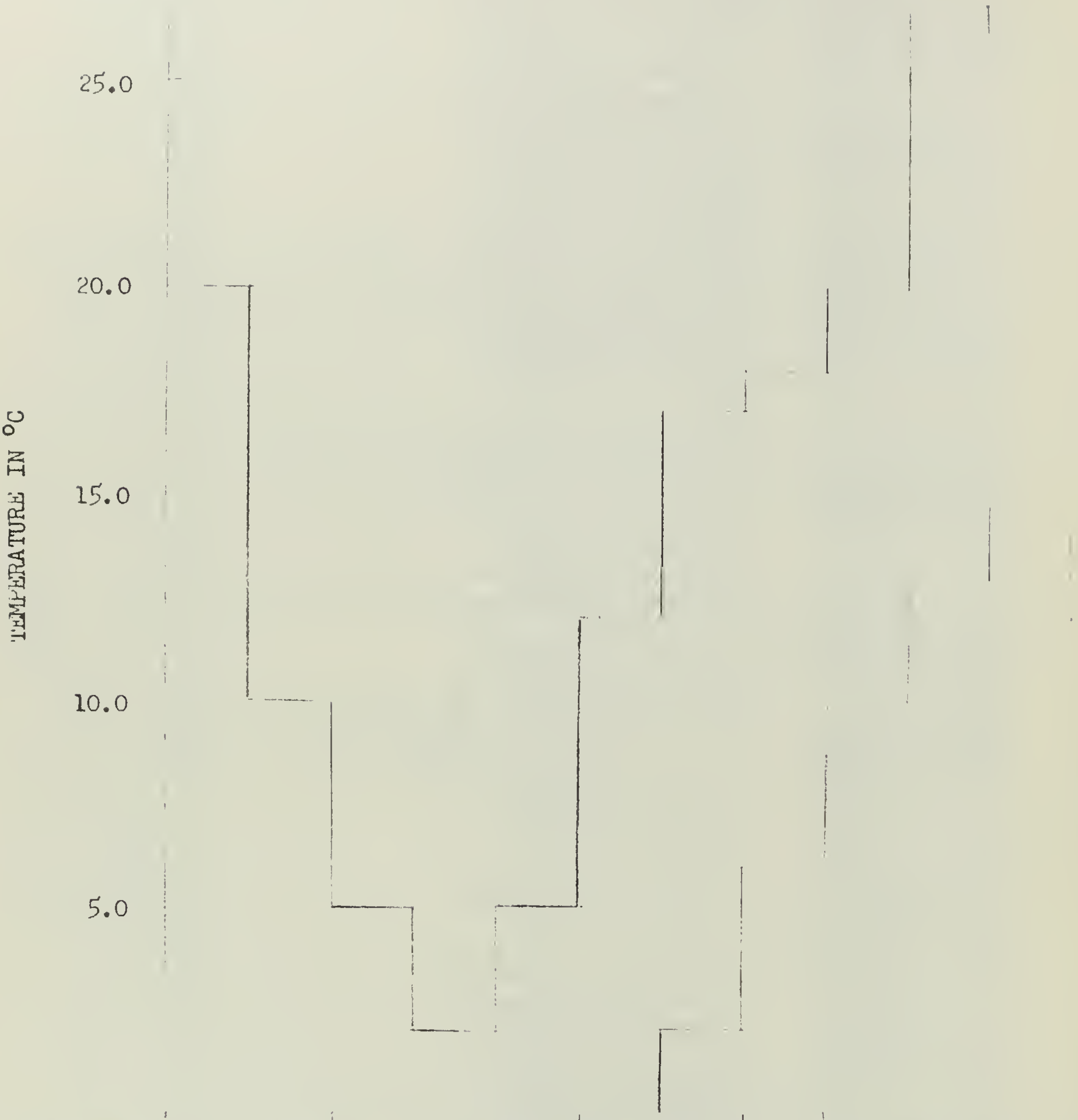
*See Appendix II

Table 16
(continued)

Sampling Site Designation	Sampling Site Location	Dates Sampled	Flow (cfs)	Temperature (°F)	pH (S.U.)	Specific Conductance umhos/cm @ 25° C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness $CaCO_3$ (mg/l)	Bicarbonate HCO_3 (mg/l)	Carbonate CO_3 (mg/l)	Alkalinity $CaCO_3$ (mg/l)	Sulfate SO_4 (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO_3 (mg/l)	Phosphate PO_4 (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
Tongue River Mainstem																																			
Tributaries (continued)																																			
Logging Creek	03S 43E 15AA	4/18/74	0.5E	9.0	8.27	[illegible]	447	10.5	1.8	0	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	2	[illegible]	19	1.0	[illegible]	[illegible]	[illegible]	0.24	<.01	<.01	<.01	<.001		[illegible]			[illegible]	8	[illegible]
Otter Creek nr Otter	07S 45E 13DC	1/30/74	2F	0.0	[illegible]	[illegible]	2698			12	169	169	[illegible]		1116	502	0	[illegible]	1465	8.6		[illegible]	[illegible]	[illegible]	0.30	0.01	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	4.3	[illegible]	[illegible]
	07S 45E 13DC	3/22/74	6.0	1.2	8.39	[illegible]	2336	13.5	2.9	0	[illegible]	167	[illegible]		896	564	5	[illegible]	1150	10.0	.6	[illegible]	[illegible]	0.36	0.10	0.01	0.02	<.001		<.01	.001		5.1	5	[illegible]
	07S 45E 13DC	5/16/74	0.3	10.5	8.21	3305	[illegible]	18.0	3.9	4	162	193	[illegible]		1199	501	0	411	1530	10.0		0.16	.03	0.15	0.02	<.01	<.01	<.001		<.001	.001		4.9	3	[illegible]
Cow Creek	06S 45E 20AA	5/16/74	0.05	7.5	8.60	583	467	9.9	1.3	>200	47	36	28		264	267	10	235	78	1.6		0.0	[illegible]	0.05	0.01	<.01	<.01	<.001		<.001	<.001		0.8	2	2.0
Otter Creek nr Ashland	03S 44E 11AD	1/17/74	4.0	0.0	8.39	3339	2861	12.0	3.3	18	131	182	434		1075	750	0	615	1351	12.0	.79	0.47	[illegible]	0.46		0.01	0.02	<.01	<.01	<.01			5.6	4	[illegible]
	03S 44E 11AD	3/22/74	7.3	1.0	8.38	2359	2304	13.1	3.7	0	90	138	359		[illegible]	528	10	449	1070	[illegible]		0.0	.03	[illegible]	0.11	<.01	0.01	<.001		<.01	.001		5.5	10	[illegible]
	03S 44E 11AD	4/18/74	6.7	13.0	8.42	2961	2533	11.1	2.5	10	92	171	400		934	590	8	497	1270	2.5	.96	0.0	<.03	0.53	0.08	0.01	0.01	<.001		[illegible]			5.7	12	[illegible]
Little Pumpkin Ck	01S 48E 11BC	5/9/74	0.2	17.9	8.11	6570	6315	10.7	2.0		164	481	1050		2390	920	0	754	[illegible]	[illegible]		0.0	<.03	0.32	0.04	0.01	<.01	<.001		[illegible]	.001		9.3	2	5.6
Pumpkin Creek near Volborg	01N 48E 11BC	4/18/74	0.1	13.0	8.30	5400	4766	9.2	3.4	0	166	218	956		1314	643	9	542	2773	0.0	.61	0.04	0.03	0.19	0.09	0.01	0.01	<.001		[illegible]			11.5	5	2.0
	01N 48E 11BC	5/9/74	0.09	16.3	8.32	5840	5394	9.1	3.2		139	253	1150		1391	673	12	572	3150	16.0		0.0	<.03	0.32	0.08	0.01	<.01	<.001		<.001	<.001		13.4	7	22.0
Pumpkin Creek S of Miles City	06N 48E 29AC	1/31/74		0.0	7.80	1035	815.[illegible]	11.9	3.8	9	65	49	90		[illegible]	306	0	251	304	1.2		0.87	0.02	0.23	0.02	<.01	<.01	<.01		<.01			2.1	10	11.0
	06N 48E 29AC	3/31/74	0.6	9.1	8.42	2564	2009	10.8	2.8	0	63	53	460		378	441	12	383	972	6.0	.32	0.0	0.05	0.30	<.07	0.01	<.01	<.01		<.01	<.001		10.3	6	13.0
	06N 48E 29AC	4/18/74	0.7	10.0	8.50	1977	1585	9.8	2.5	34	62	58	325		393	393	7	335	732	7.0													7.1	20	41.0
	06N 48E 29AC	5/9/74	0.5	19.0	8.43	3545	2759	9.4	5.9		67	58	690		403	528	7	445	1400	9.0		0.09	0.16	0.50	0.07	0.02	<.01	<.001	<.01	<.001	<.001	<.01	15.0	12	30.4
	06N 48E 29AC	5/20/74	42.7	11.5	8.33	2564	1931	10.0	5.7	5000	57	39	478		303	396	10	340	940	11.6		0.24	0.06	13.0	0.08	0.08	0.01	<.001			<.001		12.0	223	1016
Otter Creek at Ashland	03S 44E 11AD	5/9/74	5.0	18.2	8.35	3083	2776	10.0	3.9		80	182	470		950	621	12	529	1400	11.0		0.0	<.03	0.82	0.13	0.02	<.01	<.001		<.001	<.001		6.6	20	49.2

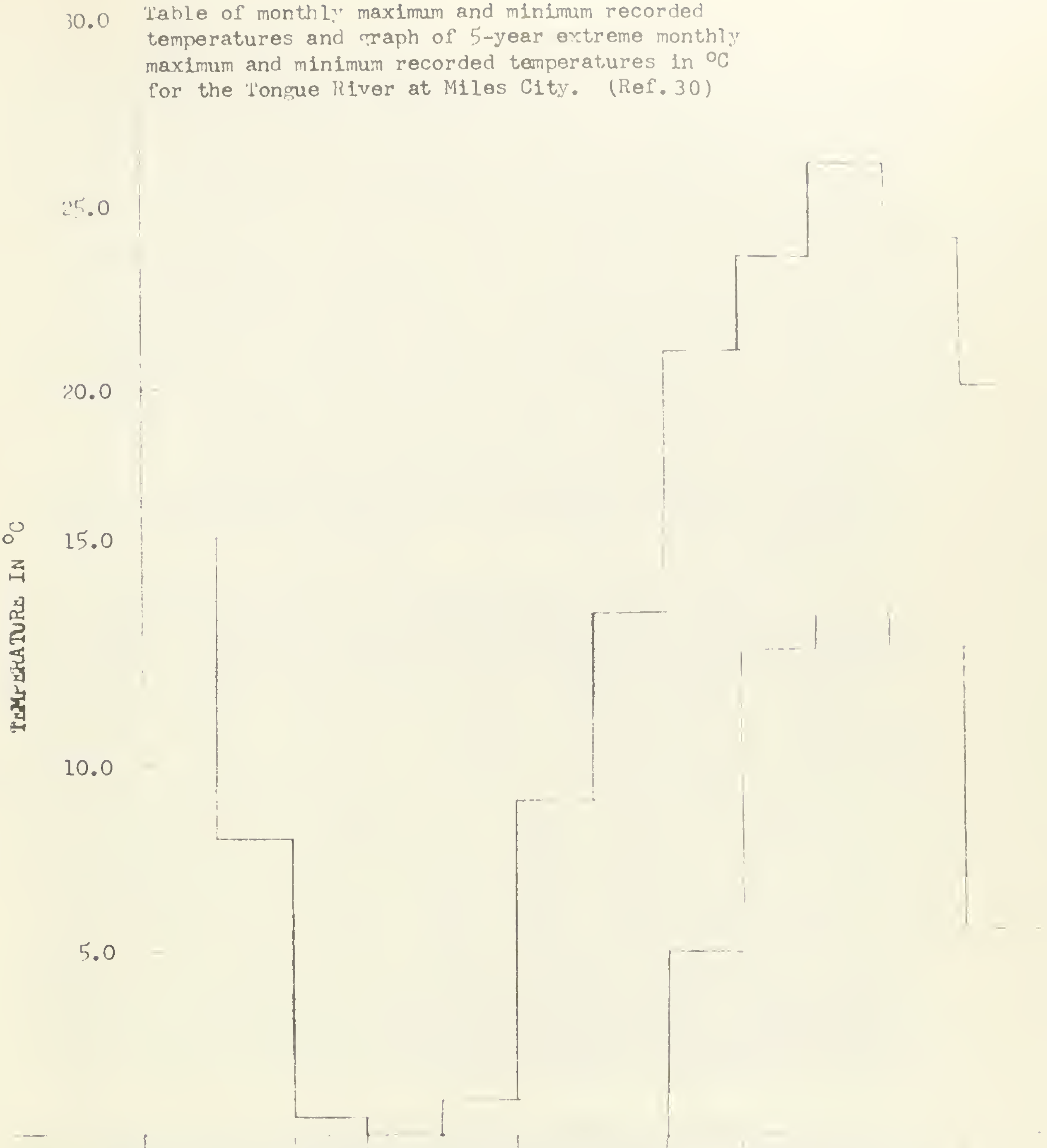
FIGURE 33

Table of monthly maximum and minimum recorded temperatures and graph of 5-year extreme monthly maximum and minimum recorded temperatures in °C for the Tongue River near State line. (Ref. 30)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1968	14	5	1	2	2	10	13	16	17	25	25	20
	6	1	1	1	1	1	2	10	10	13	15	12
1969	14.0	6.0	1.0	1.0	1.0	3.0	17.0	16.0	20.0	26.0	25.0	22.0
	4.0	1.0	1.0	1.0	1.0	1.0	3.0	7.0	10.0	17.0	18.0	12.0
1970	14.0	7.0	5.0	0.0	5.0	5.0	10.0	13.0	20.0	27.0	25.0	24.0
	3.0	0.0	0.0	0.0	0.0	0.0	4.0	6.0	10.5	19.0	16.5	7.0
1971	11.5	7.0	2.5	2.0	4.0	7.0	11.0	17.0	20.0	25.0	25.5	20.0
	3.0	0.0	0.0	0.0	0.0	0.0	4.0	8.0	10.0	17.5	18.0	8.0
1972	20.0	10.0	1.0	0.0	1.0	12.0	13.0	18.0	19.5	22.0	26.0	19.5
	0.0	0.0	0.0	0.0	0.0	0.0	3.0	7.0	14.0	14.0	16.0	8.0

FIGURE 34
Table of monthly maximum and minimum recorded temperatures and graph of 5-year extreme monthly maximum and minimum recorded temperatures in °C for the Tongue River at Miles City. (Ref. 30)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1968	15	4	0	0	1	9	12	17	20	24	21	19
	2	0	0	0	0	0	1	5	14	14	13	13
1969	14.0	8	0	0	0	4	14	21	23	26	22	20
	6.0	0	0	0	0	0	3	9	14	18	18	13
1970	16.0	5.0	0.5	0.0	0.0	0.0	10.5	18.0	22.5	24.0	22.5	19.0
	3.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	14.5	18.0	17.0	7.5
1971	12.5	4.0	0.0	0.0	1.0	6.0	12.0	19.0	13.0	21.5	23.0	20.0
	0.5	0.0	0.0	0.0	0.0	0.0	4.0	11.5	21.5	15.0	14.5	7.0
1972	10.0	4.0	0.0	0.0	0.0	9.0	11.5	19.5	17.0	21.5	24.0	17.0
	0.0	0.0	0.0	0.0	0.0	0.0	3.0	6.0	21.5	14.0	17.0	5.5

Major tributaries to the Yellowstone River in this sub-basin (the Bighorn River, Rosebud Creek, and the Tongue River) have all been discussed in the previous sub-sections of this report. Of the minor creeks sampled by the WQB in this sub-basin, the following are of interest due to the developments occurring within their drainages--Sarpy and Armells Creeks. The USGS has established water quality stations on these creeks near their confluences with the Yellowstone River. However, no data has yet been published from these sites. The WQB established sampling sites on these two creeks at the USGS stations downstream and also in their upper drainages. In addition, numerous stations were established by the WQB on Armells Creek in preparation of the WQB's input to the Energy Planning Division's (Montana State Department of Natural Resources and Conservation) environmental impact statement on coal-fired generating units 3 and 4 at Colstrip. There are also some water quality data available from Westmoreland Resources on Sarpy Creek (Plate I, Figure 1).

Table 17 shows typical water quality data for this sub-basin. Except for the sample collected during an above average runoff situation on Sarpy Creek, data in Table 17 indicates that the values of specific conductance are about 2000 micromhos. There seems to be no distinct difference between upstream and downstream stations. Values of magnesium as milliequivalents per liter are greater than that for calcium for all of the samples on Sarpy Creek except for one collected during the average average flow. Data in Table 17 for Armells Creek seems to suggest that the concentrations of dissolved constituents decrease from the upstream to the downstream sites. Sodium and sulfate concentrations for both Armells and Sarpy Creeks are exceptional in comparison to values for the Yellowstone River. Since the flows of these two creeks are generally quite small, they would usually not have a significant effect on the Yellowstone River. However, since periods of high flow of all minor streams in the sub-basin do not generally coincide with the periods of high flow on the Yellowstone, such small creeks may collectively have a significant degradation effect on the Yellowstone.

Table 17 presents data on the Yellowstone River after the confluence of the Bighorn River. There does not seem to be much variation station to station following this confluence. Data in Table 12 (Yellowstone River Sub-basin--Pryor Creek to Bighorn River) for the Yellowstone River just upstream from the confluence of the Bighorn River at Custer indicates that the concentrations of dissolved constituents increase significantly after this point. Since the Bighorn River is regulated, it seems likely that the Bighorn River would generally have the largest impact on the quality of water in the Yellowstone River during low flow periods for the Yellowstone. Loads have been determined for the Yellowstone River at Custer, the Bighorn River at Bighorn, and the Yellowstone River at Myers during a low flow period. These loads were determined from samples collected on January 22, 1974, by the Water Quality Bureau. This data is tabulated below in tons/day for selected parameters.

Stream & Site	Ca	Mg	Na	HCO_3	SO_4	Cl	TDS
Yellowstone River at Custer	600	91	370	1700	1200	80	4100
Bighorn River at Bighorn	770	150	710	1800	2500	85	6000
Yellowstone River at Myers	1400	390	1200	3600	4400	180	11000

Loads for the Yellowstone River at Forsyth, for Rosebud Creek near Rosebud, and for the Yellowstone River near Rosebud below the confluence of the Yellowstone and Rosebud Creek have been determined. These loads were determined from samples collected by the Water Quality Bureau on April 25, 1974, from the Yellowstone and on April 17, 1974, from Rosebud Creek. These dates coincided with relatively low and high flow conditions on the Yellowstone and Rosebud Creek, respectively. These loads are tabulated below in tons/day.

Stream & Site	Ca	Mg	Na	HCO_3	SO_4	TSS	TDS
Yellowstone River at Forsyth	2000	740	2000	6200	6400	3300	18000
Rosebud Creek near Rosebud	12	19	18	86	70	49	210
Yellowstone River near Rosebud	1900	740	2000	5900	6400	3200	17000

This data indicates that Rosebud Creek has a minimal effect on the water quality of the Yellowstone River. Rosebud Creek's relatively high concentrations of suspended sediment at its mouth (>100 mg/l) apparently does not increase silt loads in the Yellowstone River to any noticeable extent.

Loads for the Yellowstone River at Miles City above the confluence of the Tongue River and for the Tongue River at Miles City have been determined for both low and high flow conditions. The load for both flow conditions are tabulated in tons/day below:

HIGH FLOW

Stream & Site	Ca	Mg	Na	HCO_3	SO_4	Cl	TDS
Yellowstone River at Miles City	3400	1200	2500	12000	7700	270	22000
Tongue River at Miles City	340	210	1800	1800	1000	7.3	2900
Ratio: Tongue/ Yellowstone	.13	.18	.09	.15	.13	.03	.13

LOW FLOW

Stream & Site	Ca	Mg	Na	HCO_3	SO_4	Cl	TDS
Yellowstone River at Miles City	1100	460	1300	3600	4100	170	9200
Tongue River at Miles City	34	28	35	160	140	1.7	320
Ratio: Tongue/ Yellowstone	.03	.06	.03	.04	.03	.01	.03

It is evident that the major contribution of dissolved material by the Tongue occurs at high flow. Data used in determining these loads for high flow were from samples collected by the USGS on June 4, 1970, and June 3, 1970, for the Tongue River and the Yellowstone River at Miles City, respectively. The data used in determining loads for low flow were from samples collected by the USGS on January 8, 1970, and December 2, 1969, for the Tongue River and the Yellowstone River at Miles City, respectively.

Figure 35 includes a table of the monthly maximum and minimum water temperatures and a graph of a four-year extreme maximum and minimum temperature for the Yellowstone River at Miles City. Comparing this with Figure 26 which presents the same information for the Yellowstone River at Billings indicates that there is not much of an overall change in the extreme value, except for the late summer months when the minimum extremes for the Yellowstone at Miles City are significantly larger than for the Yellowstone at Billings.

GENERAL SUMMARY

To some extent surface water quality might be viewed as a "relative phenomenon" and is dependent upon intended water use. For example, a discussion of water quality for an industry may include different standards than water used for human consumption and fisheries maintenance. This is illustrated by Montana Water Quality Standards (Appendix B) where the State has set more stringent criteria for the "A" and "B" classes of water (suitable for human consumption after treatment) than for the "C" class (recreation or for waters

Table 17
Typical chemical analysis of water in the Yellowstone River sub-basin--
Bighorn River to Tongue River.

Sampling Site Designation	Sampling Site Location *	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25°C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness $CaCO_3$ (mg/l)	Bicarbonate HCO_3 (mg/l)	Carbonate CO_3 (mg/l)	Alkalinity $CaCO_3$ (mg/l)	Sulfate SO_4 (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO_3 (mg/l)	Phosphate PO_4 (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorption Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids TSS (mg/l)
Yellowstone River Mainstem																																			
at Myers	06N 35E 21DB	1/22/74	7680	0.0	7.78	729	538	12.2	3.8	70	65	18.9	58		240	174	0.0	143	210	8.5		3.2	0.13	1.6	0.08	<.01	<.01	<.01			0.002		1.6	39	94.0
	06N 35E 21DB	4/25/74	12360	11.9	8.13	759	573	10.2	1.9	20	57	28	66		259	194	0	159	218	8.8		0.66	0.10	1.4	0.11	0.02	<.01	<.001			<.001		1.8	26	76.0
	06N 35E 21DB	4/25/74	12360	13.1	8.08	693	518	10.0	1.9	34	60	21	58		237	184	0	151	185	9.4		0.64	0.11	1.1	0.10	0.02	<.01	<.001			<.001		1.6	22	58.0
at Forsyth	06N 40E 22AA	7/16/73	10800	23.8	8.30	450	342	8.9		9	3.7	15	37		154	131	0.0	107	117	4.6	.31	0.19	0.06	0.02			<.01	<.01	<.01	<.01			1.3	13	
	06N 40E 22AA	12/13/73	7400	2.0	7.89	782		12.8	2.6	1														0.21		<.01	<.01	<.01	<.01					6	8.8
	06N 40E 22AA	3/13/74	7740	5.6	8.41	790	660	12.1	2.9	0	74	26	81		292	193	7.0	169	268	10.4	.46	0.32	0.12	0.39	0.04	0.01	0.01	<.01	<.01		<.001		2.1	4	11.0
	06N 40E 22AA	4/25/74	11870	14.3	8.18	704	552	9.3	2.1	130	63	23	63		251	192	0	158	200	9.6		0.70	0.11	1.7	0.12	0.02	<.01	<.001			<.001	<.01	1.7	38	104
	06N 40E 22AA	6/10/74	33800	12.8	8.22	499	357	8.7	3.6		43	9.1	46		146	122	0	100	131	5		0.49	0.15	12	0.52	0.07	0.01	<.001			<.001		1.7	210	992
	06N 40E 22AA	6/20/74	61800	18.5	8.21	250	200				32	4.2	17		97	99	0	81	44	3.3		0.78	0.24	9.0	0.42	0.04	0.01	<.001		.001	<.001	0.02	0.8	300	
near Rosebud	06N 42E 15BC	1/21/74	9570E	0.0	7.94	622	467	12.3	4.6	20	54	18	52		208	151	0.0	124	183	7.0		2.1	0.13	1.6	0.03	<.01	<.01	<.01			0.002		1.6	28	54.0
	06N 42E 15BC	3/13/74	7830	6.0	8.40	810	668	12.3	3.3	10	72	28	81		294	202	5.0	174	270	9.6		0.66	0.11	0.66	0.05	<.01	<.01	<.01	<.01		<.001		2.1	6	14.0
	06N 42E 15BC	3/13/74	7830	6.0	8.40	600	652	12.2	2.9	10	71	27	80		286	179	12	167	273	9.0	.48	0.62	0.06	0.29	0.05	<.01	<.01	<.01	<.01		<.001		2.1	3	10.0
	06N 42E 15BC	4/25/74	11380	14.4	8.11	688	560	9.4	2.1	84	63	24	64		254	191	0	157	208	8.8		0.70	0.12	1.7	0.11	0.02	0.01	<.001			<.001		1.7	38	104
at Miles City	08N 47E 28BB	7/16/73	11100	24.7	8.51	582	350	9.0	1.9		39	16	35		165	132	4.0	114	118	4.1	.31	0.89	0.01	0.02		0.03	<.01	<.01	<.01	<.01			1.2	14	
	08N 47E 28BB	3/31/74	9300	8.7	8.38	847	638	11.1	1.1	0	69	29	75		292	190	5.0	164	261	9.1		0.32	0.06	0.30	0.03	<.01	<.01	<.01		<.01	<.001		1.9	6	14.0
	08N 47E 28BB	4/25/74	11800	17.0	8.21	686	578	9.1	2.1	108	65	23	63		258	[illegible]	0	155	227	9.6		0.78	0.11	1.8	0.12	0.02	0.01	<.001			<.001	<.01	1.7	42	116
	08N 47E 28BB	6/11/74	35100	13.6	7.58	441	342	8.7	3.8		43	11.2	40		152	122	0	100	120	5.5		0.67	0.12	0.97	0.51	0.06	<.01	<.001		<.001	<.001		1.4	185	760
	08N 47E 28BB	6/11/74	35100	12.8	7.83	485	337	8.0	3.2		39	11.5	42		145	113	0	93	124	5.8		0.93	0.15	11.0	0.44	0.06	0.01	<.001		<.001	<.001		1.5	220	926
at Miles City	08N 47E 31BC	6/3/70	31100	17.0	7.9	439	265				39	14	30	2.6		142	0.0		91	3.2	.3			.614											
	08N 47E 31BC	6/7/71	32000	15.0	8.1	403	255				36	12	29	1.9		123	0.0		98	3.9	.3		0.09	0.04											
	08N 47E 31BC	6/7/72	48400	20.0	6.8	247	150				23	70	15	1.5		83	0.0		47	2.8	.3			0.08											
	08N 47E 31BC	12/9/68	7640	0.0	7.7	702					57	22	61	3.9		189	0.0		202	9.6	.4	2.2		.180											
	08N 47E 31BC	12/2/69	6800	1.0	7.9	764	499				61	25	69	4.4		196	0.0		223	9.0	.6			.046											
	08N 47E 31BC	12/7/70	6840	0.5	7.0	668	443				58	21	55	4.1		192	0.0		190	9.8	.4			.060											
	08N 47E 31BC	9/9/69	6900	20.0	8.1	724					59	23	70	4.3		196	0.0		210	6.8	.5	0.10		.090											
	08N 47E 31BC	9/9/70	6610	17.0	7.6	625	401				51	18	54	4.1		178	0.0		166	9.2	.5														
	08N 47E 31BC	9/1/71	10300	22.0	7.6	534	340				41	15	46	3.4		167	0.0		130	8.1	.9		0.06	.030											
Tributaries																																			
Alf Creek	07N 36E 22DC	2/9/74	.2	1.5	7.00	146	86	12.0	8.0	235	9.0	3.3	12		36	38	0	31	20	2.2		0.91	0.69	7.8		0.07	<.01	<.01	<.01		<.001		0.9	128	184
Proze-to-Death Creek	07N 36E 26AA	2/9/74	.2	1.0	7.17	132	108	11.7	4.9	0	7.1	2.0	20		26	33	0	27	44	0.6		0.42	0.61	2.8		<.01	<.01	<.01	<.01		<.001		1.7	66	96.0
Sarpy Creek																																			
below Westmoreland	01N 37E 16DA	1/18/74	25.9	0.0	7.01	283	187	11.1	11.1	500	18.8	9.2	20		85	76	0	62	56	5.0	.05	1.3	0.92	22		0.01	<.01	<.01	<.01	<.01			0.9	82	190
		1/31/74	0.0	0.0	7.40	2584	2245	4.7	2.4	11	142	203	194		1188	640	0	525	1059	6.3		1.25	0.10	0.67	1.1	0.03	<.01	<.01	<.01	<.01		0.01	2.4	4	5.0
		3/19/74	1.0	1.0	8.00	2270	2041	10.5	4.1		120	177	196	12	1028	608	0	498	920	8.0	.27	0.0	<.03	0.60	0.11	<.01	0.02	<.001		<.01			2.7	8	6.0
E of Hysham	06N 37E 18AB	12/27/73	2.8	0.0	8.31	2395	2037	12.8	3.0	18	86	78	400		535	576	0	472	883	14.2	.43		0.01	0.31		0.01	<.01	<.01	<.01	<.01			7.3	5	6.0
	06N 37E 18AB	2/9/74	3.7	0.0	8.20	1793	1390	11.4	2.8	20	74	62	238		440	426	0	349	582	7.2		0.78	0.25	0.60		<.01	<.01	<.01	<.01		<.001		4.9	9	9.5
	06N 37E 18AB	4/17/74	3.2	10.5	8.34	2656	2269	10.4	2.7	29	91	129	385		758	556	0	456	1096	11.8													6.1	10	14.0
	06N 37E 18AB	6/11/74	30.2	16.7	8.12	2205	1849	8.1	6.3		107	88	325		630	329	25	311	962	12.5		0.06	0.06	3.0	0.17	0.02	<.01	<.001		0.002	<.001	0.01	5.6	51	159
Starved-to-Death Creek	07N 37E 26AC	2/9/74	0.9	1.0	6.80	1768	1313	12.0	4.2	80	63	39	296		318	18	0	15	886	3.6		6.6	0.0	5.8		0.04	<.01	<.01	<.01		<.001		7.2	98	220
	07N 37E 26AC	4/19/74	0.01	17.7	7.39	2263	1669	9.8	3.4	0	95	43	360		417	41	0	34	1124	4.0	.46	0.0	0.03	0.16	<.01	0.01	0.01	<.001			<.001		7.7	4	6.5
Reservation Creek	06N 38E 35CB	12/27/73	0.9	0.0	8.45	1945	1637	12.9	1.9	5	96	69	278		525	436	0	357	745	12.6	.34		0.01	0.18		<.01	<.01	<.01	<.01	<.01			5.3	4	3.5
	06N 38E 35CB	2/16/74	1.2	2.0	8.00	1591	1513	12.2	2.7	110	98	69	244		530	432	0	354	660	9.4		0.47	0.12	0.49		0.01	<.01	<.01	<.01		<.001		4.6	11	23.5
	06N 38E 35CB	4/19/74	0.8	13.0	7.89	1918	1356	10.5	2.5	74	91	69	198		512	458	0	375	539	0.5	.52	0.0	0.03	0.54	0.01	0.01	0.01	<.001			<.001		3.8	12	21.5
Great Porcupine Creek	06N 39E 11CA	11/30/73		0.0	7.39	2050	1698				150	60	257		621	451	0	370	744	35		0.39	0.04										4.5	8	
	06N 39E 11CA	1/24/74	0.5	0.0	6.61	1071	695	11.1	8.2	0	51	11.1	145		174	63	0	52	410	5.0		8.3	0.31	1.5	0.01	<.01	0.01	<.01			0.002		4.8	27	62.0
	06N 39E 11CA	4/18/74	0.0	16.8	7.92	2066	1627	10.4	4.3	2	112	66	275		554	247	0	203	910	15.0	.44	0.0	0.03	0.78	0.22	0.01	<.01	<.001			<.001		5.1	16	28.0
Armells Creek																																			
E Fork at Colstrip	01N 41E 03BB	10/24/73	0.2		8.20	3850	3679				285	362	272		2200	644	0	528	2078	38	.33	0.45	0.86	0.40		0.04	<.01	<.01	0.01	<.01			2.5	1	
	01N 41E 03BB	1/25/74	0.05	2.0	7.21	2826	2584	1.9	1.9	0	261	220	160		1555	602	0	494	1328	12.8		0.78	0.28	2.7	3.0	0.06	0.01	<.01			<.001		1.8	39	39.0
	01N 41E 03BB	4/16/74	0.2	11.8	7.81	3055	2845	10.7	2.4	0	228	281	173		1728	599	0	491	1563	0.2	.30	0.04	<.03	0.41	1.5	0.03	0.01	<.001			<.001		1.8	4	7.2
E Fork N of Colstrip	03N 41E 28CC	3/14/74	0.9	4.1	7.97	5043	4885	12.5	5.0	1	207	487	525		2520	592	0	485	3048	26	.27	0.19	0.09	0.78	0.91	0.02	0.01	<.01	<.01		<.001		4.6	11	26.0
	03N 41E 28CC	4/16/74	2.0	15.0	8.10	4858	4686	11.9	2.8	36	248	452	488		2460	558	0	458	2904	35	.22	0.0	<.03	0.38	0.18	0.01	0.01	<.001			<.001	0.02	4.3	8	18.0
E Fork at Hwy 315	04N 40E 22CA	1/25/74	2.8	2.2	7.98	2096	1639	10.5	4.0	0	124	91	228		682	285	0	234	891	20		0.75	0.11	0.08	<.01	<.01	0.03	<.01			0.001		3.8	2	3.8
	04N 40E 22CA	4/16/74	2.2	24.0	8.31	4460	4002	8.0	1.7	0	216	212	669		1412	506	0	419	3286	9.0	.31	0.18	0.03	0.34	0.21	0.01	0.03	<.001			<.001		7.7	20	28.0

* See Appendix II

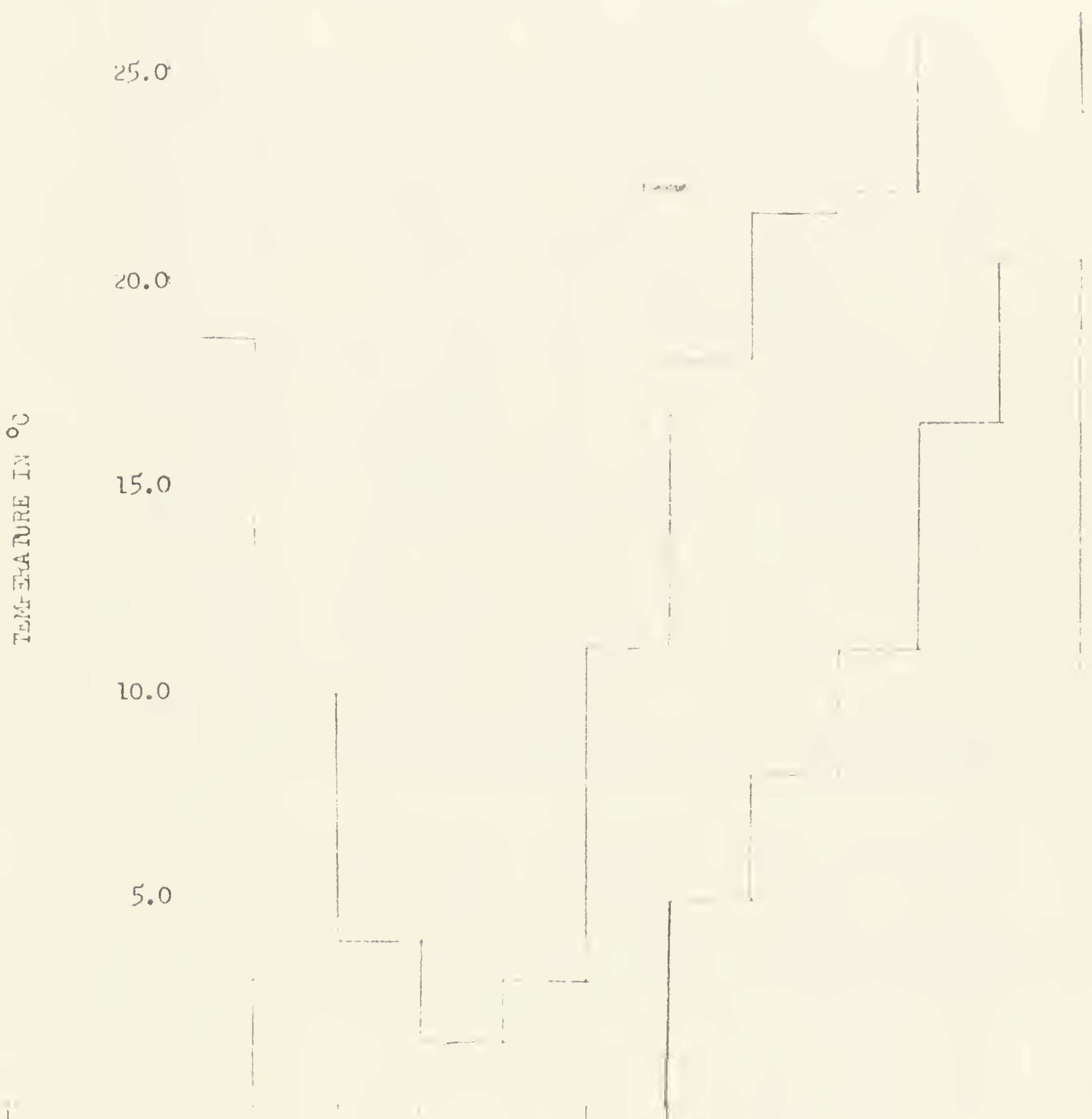
Table 17
(continued)

Sampling Site Designation	Sampling Site Location *	Dates Sampled	Flow (cfs)	Temperature (°C)	pH (S.U.)	Specific Conductance umhos/cm @ 25° C	Calculated Dissolved Solids (mg/l)	Dissolved Oxygen DO (mg/l)	Biological Oxygen Demand BOD (mg/l)	Fecal Coliform (counts/100 ml)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Total Hardness CaCO$_3$ (mg/l)	Bicarbonate HCO$_3$ (mg/l)	Carbonate CO$_3$ (mg/l)	Alkalinity CaCO$_3$ (mg/l)	Sulfate SO$_4$ (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO$_3$ (mg/l)	Phosphate PO$_4$ (mg/l)	Iron Fe (mg/l)	Manganese Mn (mg/l)	Zinc Zn (mg/l)	Copper Cu (mg/l)	Cadium Cd (mg/l)	Lead Pb (mg/l)	Arsenic As (mg/l)	Mercury Hg (mg/l)	Chromium Cr (mg/l)	Sodium Adsorptic Ratio SAR	Laboratory Turbidity (JTU)	Total Suspended Solids (mg/l)
Yellowstone River Mainstem																																			
Tributaries (continued)																																			
Armells Creek																																			
Upper West Fork	03N 39E 26AC	4/14/74	1.6	15.0	8.20	5440	5026	9.50	1.5	6	192	301	888		1720	640	5	533	2999	0.2	.27	0.0	<.03	0.25	0.07	0.01	0.01	<.001			<.001		9.3	17	16.8
W Fork nr Hwy 315	04N 40E 16AB	1/25/74	3.1	2.0	7.92	3272	2769	11.0	4.4	0	167	132	468		962	412	0	338	1570	17.8		1.6	0.17	0.39	0.26	<.01	0.02	<.01			<.001		6.6	2	10.5
	04N 40E 16AB	4/15/74	2.8	11.6	8.16	4190	3604	11.3	4.0	190	176	164	675		1116	522	5	436	2049	12.0	.44	0.0	<.03	0.65	0.15	0.01	0.01	<.001			<.001	0.04	8.8	18	28.0
at Highway 315	05N 39E 36BB	1/25/74	4.5	0.0	7.96	2280	1735	11.7	6.0	0	104	68	323		540	318	0	261	908	13.3		0.66	0.11	0.61	0.20	0.01	0.01	<.01			0.004		6.0	15	37.3
	05N 39E 36BB	4/16/74	4.2	13.5	8.21	3210	2634	11.3	3.6	32	124	97	538		710	413	0	339	1444	17.0	.27	0.06	0.03	0.35	0.33	0.02	0.01	<.001			<.001	0.05	8.8	36	38.0
W of Forsyth	06N 39E 23AC	12/14/73	1.9	3.1	8.32	3880		13.3	2.1	2														0.16		0.02	0.01	<.01	0.01					8	24.8
	06N 39E 23AC	1/22/74	9.2	0.0	7.80	1006	701	11.6	11.0	1120	62	58	138		178	194	0	159	292	8.2		1.4	0.23	3.4	0.15	0.01	0.02	<.01			0.01		4.5	72	180
	06N 39E 23AC	3/1/74	2.3	4.7	8.18	2914	2301	11.8	4.7	260	63	70	525		447	512	0	420	1118	12.0		0.31	0.49	1.8		0.02	<.01	<.01	<.01	<.01	<.001	0.01	10.8	33	64.0
	06N 39E 23AC	4/16/74	4.2	14.0	8.23	2628	2095	11.0	3.5	212	92	67	441		504	380	0	312	1100	14.0		0.27	0.06	1.8	0.21	0.02	<.01	<.001			<.001	0.05	8.5	43	93.0
	06N 39E 23AC	4/17/74	4.2	13.5	8.31	3304	2796	10.9	3.6	50	99	99	606		656	463	6.0	389	1500	23													10.3	26	64.0
	06N 39E 23AC	6/20/74	18.3	27.2	8.21	650		8.4			39	13	82		152	134	0	110	204	5.5		0.55	0.17	9.2	0.32	0.03	<.01	<.001		.005	<.001	0.01		270	380
Sheep Creek	04N 40E 22BB	4/16/74	0.1	18.2	8.12	703	514	8.4	5.3	0	11.2	22.9	138		40	180	0	148	170	2.0		8.0	0.92	1.8	0.16	0.14	0.03	<.001			<.001		9.5	155	245
Smith Creek	06N 40E 28AA	2/9/74	0.3	1.5	8.17	1762	1377	11.7	2.9	0	44	29	312		230	529	0	434	462	0.2		0.53	0.04	0.36	0.04	0.01	<.01	<.01			<.001		8.9	8	11.5
	06N 40E 28AA	4/19/74	0.2	12.3	8.23	2154	1778	10.4	1.6	0	46	34	431		256	608	10	516	648	0.0	.80	0.0	0.03	0.20	<.01	0.01	0.01	<.001			<.001	0.03	11.7	14	17.6
Little Porcupine Creek	06N 41E 02DC																																		
	06N 41E 02DC	11/29/73		0.0	7.31	3480	1077				77	26	208		299	290	0	238	422	48		4.76	0.03										5.2	13	
	06N 41E 02DC	2/9/74	2.3	0.0	7.72	3821	3106	10.2	3.1	10	353	95	476		1272	257	0	211	1667	257		1.2		0.35	0.34	0.01	<.01	<.01			<.001		5.8	11	16.0
	06N 41E 02DC	4/18/74	2.9	15.0	7.81	4802	3958	10.5	4.1	6	465	106	594		1598	203	0	167	2238	349	2.7	0.0	0.06	0.90	0.50	0.01	0.02	<.001			<.001	0.04	6.5	24	38.0
Sweeney Creek	06N 43E 22AD	1/21/74	1.5	0.0	7.78	807	606	11.8	10.1	460	57	0.0	116		142	218	0	179	205	8.3		1.9	0.18	1.8	0.08	<.01	0.01	<.01			0.001		4.2	53	108
	06N 43E 22AD	4/18/74	0.7	19.5	8.41	2073	1682	10.6	2.6	2	50	34	400		266	504	10	431	670	12.0	.86	0.0	0.03	0.89	0.11	0.01	<.01	<.001			<.001		10.7	23	37.0
Moon Creek	07N 46E 30DA	3/31/74	0.2	9.2	8.30	2200	1728	10.7	1.1	0	67	40	388		334	481	20	428	716	14.8	.25	0.0	0.03	0.23	0.06	<.01	<.01	<.01		.01	<.001		9.2	2	4.5
	07N 46E 30DA	6/10/74	1.3	16.2	7.72	962	732	8.4	6.4		39	0.8	179		101	231	9	204	268	4.7		0.68	0.29	6.5	0.18	0.06	<.01	0.001			<.001		7.7	205	482

* See Appendix II

FIGURE 35

Table of monthly maximum and minimum recorded temperatures and graph of 4-year extreme monthly maximum and minimum recorded temperatures in °C for the Yellowstone River at Miles City. (Ref. 30)



Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SPT
1969	13	10	2	0	0	7	18	21	22	25	26	24
	9	2	0	0	0	0	6	11	12	19	23	16
1970	16.0	8.0	4.0	1.5	3.0	8.0	12.0	19.0	21.0	26.0	26.0	24.0
	3.5	1.5	0.0	0.0	0.0	0.0	5.0	10.0	14.5	18.0	23.5	11.0
1971	16.0	6.5	1.0	1.0	2.0	8.0	12.0	19.0	19.5	23.0	26.5	22.0
	5.0	0.0	0.0	0.0	0.0	0.0	6.5	11.0	11.0	16.5	20.5	11.5
1972	18.5	7.0	4.0	1.0	0.0	11.0	13.0	21.5	21.0	24.0	24.0	23.0
	3.0	2.0	0.0	0.0	0.0	0.0	6.0	8.0	18.0	17.0	22.0	10.0

deigned for industrial or agricultural use ("E" and "F" classes).

In general surveillance and inventory work, general discussions of water quality often become restatements of the tabular summaries since no central focus for the discussion is available in terms of a specific water use. Therefore, to serve as a comparative guideline for this particular discussion of water quality in the Middle Yellowstone Basin, those criteria established relative to human use will serve as the primary reference point. All waters in the basin are of the B-D class (Appendix B). Water quality of the area is compared to Montana water quality criteria and to three other criteria (Table 18). Standards were selected from these sources as they specifically relate to the water quality parameters monitored in this particular survey.

Dissolved oxygen (DO) is a critical parameter in consideration of water quality. This relates primarily to biological and ecological factors rather than to human use although surface waters with a low DO content may be indicative of organic pollution and of water unfit for human use. Biologically, game fish require DO concentrations of at least 5 ppm to reproduce and generally die if DO falls below 3 ppm (Ref. 50). Montana criteria for oxygen in "D_1", "D_2", and "D_3" class streams are listed in Appendix B. With few exceptions, DO concentrations in streams of the basin were at or near saturation. Dissolved oxygen ranged from about 7.7 to 13.5 mg/l; the higher values were obtained during the winter with water temperatures approaching 0°C. As a result, DO values in the basin were typically greater than the minimum Montana requirements for salmonid propagation (Appendix B). The few exceptions related primarily to the smaller streams such as Sarpy Creek with such samples representing unique cases even for these waters.

Consistently high DO values in the streams indicate an absence of organic pollution. This is confirmed by data from the numerous five-day biological oxygen demand (BOD_5) determinations made through the sampling program. Typically BOD was less than 5 mg/l for most stream samples. A few BOD's ranged from 5 to about 11.5 mg/l. However, even these values are not exceptionally high. Sewage effluents generally range between 40 and 80 mg/l with a well operated and functional lagoon system but approaching 140 mg/l and in some cases exceeding 200 mg/l with poorly managed or nonfunctional systems.

Table 18

Selected water quality criteria and standards as compiled by three sources: A--Public Health Service, "Drinking Water Standards" (Ref.47),; B--National Technical Advisory Board, "Surface Water Criteria for Public Supplies" (Ref. 48); and C--California State Water Quality Control Board, "Water Quality for Livestock" (Ref. 49). Concentrations are listed as milligrams per liter where appropriate, temperature in degrees centigrade, turbidity in JTU, and bacteria as number per 100 ml; ab--virtually absent; sat--near saturation.

	A[1]	B		C	
Constituent	Standard	Permissible Criteria	Desirable Criteria	Threshold Concentration	Limiting Concentration
Temperature		24			
Turbidity	5	75	absent		
Dissolved Solids	500	500	<200	2500	5000
pH		6.0-8.5		6.0-8.5	5.6-9.0
Fecal Coliforms		2000	<20		
Bicarbonate				500	500
Calcium				500	1000
Chloride	250	250	<25	1500	3000
Fluoride				1.0	6.0
Magnesium				250	500
Sodium				1000	2000
Sulfate	250	250	<50	500	1000
Arsenic	0.01	0.05	None	1.0	
Boron		1.0	ab		
Cadmium	0.01	0.01	None	5	
Chromium	0.05	0.05	None		
Copper	1.0	1.0	ab		
Iron	0.3	0.3	ab		
Lead	0.05	0.05	None		
Manganese	0.05	0.05	None		
Selenium	0.01	0.01	ab		
Zinc	5.0	5.0	ab		
Dissolved Oxygen		>3	sat		

[1] Applicable after treatment

Streams in the basin with BOD_5 values greater than 5 mg/l were typically smaller streams such as Hanging Woman, Lame Deer, Pumpkin, Moon, Sarpy, and Sweeney Creeks. High BOD_5 values were also obtained for various sites and dates in Armells and Rosebud Creeks. For major rivers and creeks in the basin, excepting Rosebud Creek, BOD_5 values were typically less than 5 with 3 mg/l perhaps representing a valid median estimate.

The general absence of municipal pollution from streams in the Middle Yellowstone Basin is also illustrated by the bacteriological data. Fecal coliform/fecal strep ratios were consistently less than one which suggests a predominance of animal wastes entering the waters rather than human contamination (Ref. 51). Fecal coliform counts varied widely at any given site between sampling dates and between streams. This data demonstrated a general positive correlation with flow. Typically, counts were much less than the "permissible criteria" of Table 18 but often greater than that level deemed "desirable" by the National Technical Advisory Board (Ref. 48) and occasionally greater than the standards established by the State of Montana for "B" class waters (Appendix B). During periods of above average stream flow, 1.5% of the samples exceeded 2000 counts of fecal coliform colonies per 100 ml; 9% of the samples exceeded 200 counts/100 ml, and 6% exceeded 400 counts/100 ml. Streams with counts most consistently greater than 200/100 ml were Armells, Rosebud, and Rotten Grass Creeks (2-3 samples). Pumpkin, Pass, Owl, Soap, Sarpy, Sweeney, Lame Deer, and Hanging Woman Creeks had single samples that exceeded 200 colonies/100 ml.

Water temperatures ranged from zero during the winter to between 25 and 30°C during the summer which is typical of warm water habitats. Turbidities varied markedly from stream to stream and with flow. Turbidities were typically less than 60 JTU and less than the "permissible criteria" of Table 18. In 12% of the samples, turbidities were found to range higher than 75 JTU and therefore exceeded this criteria. Markedly high values for turbidity were obtained for Armells, Rosebud, Pumpkin, and Tullock Creeks and for the Yellowstone and Tongue Rivers during periods of high flow (180-270 JTU).

Turbidity, total suspended solids (TSS), and flow were found to be positively related. As a result, TSS values also demonstrated wide fluctuations between dates and streams. For example, in the Yellowstone River, TSS ranged from 8.8

to 992 mg/1 on different dates at Forsyth corresponding to flows of 7400 to 33,800 cfs respectively. Similar wide fluctuations were evident in the smaller streams: Starved to Death Creek--6.5-220 mg/1, 0.01-0.9 cfs; Pumpkin Creek 13.0-1016 mg/1, 0.60-42.7 cfs; and Moon Creek--4.5-482 mg/1, 0.2-1.3 cfs. Rosebud Creek and Pryor Creek were unique in possessing consistently high TSS values through the lower reaches irrespective of flow with a range for the former of 130 to 536 mg/1 at the flow extremes. Pryor Creek is exceptional in the extremely high TSS values obtained for certain of its samples as compared to the remainder of the Middle Yellowstone Basin (values of 1,720 and 3,426 mg/1). TSS values obtained during the sampling period can be classified as follows:

TSS Range (mg/1)	Class %	Accumulative %
<10	15	15
10-25	26	41
25-50	16	58
50-100	14	72
100-150	9	81
150-200	4	85
200-400	6	91
400-600	4	96
600-800	<1	96
>800	4	100

Many streams in the basin had TSS greater than 200 mg/1 during periods of above average flow. The modal range of TSS in the basin would be 10-25 mg/1; a median value would be only slightly greater than 25 mg/1.

Dissolved solids in the streams of the study area were relatively high and exceeded recommended public water supply and drinking water standards in many cases. Concentrations were consistently highest in the smaller streams such as Armells, Little Porcupine, Reservation, Otter, and Pumpkin Creeks which have their headwaters in the basin and concentrations greater than 1,000 mg/1 were typical. In some instances, dissolved solids concentrations exceeded the threshold concentrations for stock water (Table 18) (e.g., in Little Porcupine and Otter Creeks and primarily in Armells Creek). In contrast, larger streams including Rosebud Creek had dissolved solids typically ranging between 500 and 1,000 mg/1. Of the larger streams, the Yellowstone River and the Little Bighorn River had the lowest dissolved solid concentrations in the basin generally followed in order by the Bighorn River, Tongue River and Pryor Creek, by the various tributaries of the Little Bighorn and Bighorn Rivers, and finally by Rosebud Creek.

Water quality in the study area varies widely from stream to stream and seasonably. The waters are hard to very hard with moderate to high dissolved solids. Streams are of a calcium-sodium, sulfate-bicarbonate composition. Magnesium is abundant and often exceeds calcium on a milliequivalence basis. Generally, the quality of surface water in the basin can be described as poor to fair (Ref. 52).

With few exceptions, fluorides in basin surface waters were below the upper limits for drinking water established at 0.8 to 1.7 mg/l; this criteria is inversely dependent upon average maximum air temperatures (Ref. 47). Chlorides and potassium had low concentrations in streams. Bicarbonate, carbonate, and sulfate were dominant anions. Sulfate exceeded the recommended criteria for human use in many streams (including the Yellowstone River). In some smaller streams, both sulfate and bicarbonate exceeded threshold concentration for livestock.

Sodium was a common cation in all basin waters and was the dominant cation in many streams. However in only a very few cases were the sodium threshold values for livestock exceeded. Sodium is of added interest in terms of a water's use for irrigation. High sodium adsorption ratios (SAR) for a water are indicative of potential hazards in irrigation (Ref. 53).

As with many of the other parameters, phosphate and nitrate concentrations varied with season and location throughout the basin. For example, nitrate (as NO_3) concentrations in Armells Creek at Forsyth ranged from 1.4 to 0.0 mg/l in January and July of 1974 respectively. Phosphate (as PO_4) concentrations in the Little Bighorn River near Hardin ranged from 0.82 to 0.05 mg/l in March and May. Nitrate and phosphate concentrations in Moon Creek were 0.68 and 0.29 mg/l respectively in contrast to values of 0.06 mg/l for both NO_3 and PO_4 in Sarpy Creek near Hysham on a similar date. However, Moon Creek had nitrate and phosphate values similar to those of Sarpy Creek 2 1/2 months earlier (0.0 and 0.03 mg/l respectively).

With the exception of iron and manganese, the concentrations of the metals were generally less than the maximum values suggested for human use (Table 18). Both iron and manganese exceeded the recommended standards in some samples. This is also illustrated in Table 19 which summarizes the results of an extensive and special metals analysis on selected samples. With the exception of iron, manganese, vanadium, and boron, median concentrations for metals tested were not high. Iron and manganese are normally removed in conventional water treatment processes so these are not considered a problem in water supplies receiving treatment such as with the surface supplies currently taken from streams in the basin. The PHS Drinking Water Standards are applicable after treatment.

Table 19

Special metals analysis on selected samples collected by the Water Quality Bureau in 1974.

Site No.	Station	Date
1.	Little Bighorn River north of Wyola	5/14/74
2.	Little Bighorn River near Hardin	5/14/74
3.	Owl Creek near Lodge Grass	5/1/74
4.	Lodge Grass Creek at Lodge Grass	5/15/74
5.	Bighorn River south of Hardin	5/16/74
6.	Bighorn River near Bighorn	5/16/74
7.	Tullock Creek near Bighorn	6/11/74
8.	Sarpy Creek east of Hysham	6/11/74
9.	Sarpy Creek east of Hysham	7/31/74
10.	Smith Creek near Forsyth	4/19/74
11.	Little Porcupine Creek north of Forsyth	4/18/74
12.	East Fork of Armells Creek north of Colstrip	4/16/74
13.	East Fork of Armells Creek north of Colstrip	7/31/74
14.	West Fork of Armells Creek near Hwy 315	4/15/74
15.	Armells Creek at Hwy 315	4/16/74
16.	Armells Creek west of Forsyth	4/16/74
17.	Armells Creek west of Forsyth	6/20/74
18.	Armells Creek west of Forsyth	7/31/74
19.	Yellowstone River near Custer	4/25/74
20.	Yellowstone River at Forsyth	4/25/74
21.	Yellowstone River at Forsyth	6/19/74
22.	Yellowstone River at Miles City	4/25/74
23.	Rosebud Creek south of Kirby	4/30/74
24.	Rosebud Creek south of Colstrip	4/30/74
25.	Rosebud Creek south of Rosebud	6/20/74
26.	Rosebud Creek near Rosebud	4/30/74
27.	Rosebud Creek near Rosebud	7/31/74
28.	Tongue River in Montana near Decker	5/8/74
29.	Tongue River Irrigation Reservoir	5/8/74
30.	Tongue River southwest of Birney	5/9/74
31.	Tongue River near Miles City	5/9/74
32.	Tongue River near Miles City	6/10/74

Table 19

Site No.	As	Be	B	Cd	Cr	Co	Cu	Fe	Li	Hg	Mn	Se	V	Zn
1.	<.001	<.01	.18	<.001	<.01	<.01	<.01	.70	.01	<.001	.05	<.001	.03	.01
2.	<.001	<.01	.05	<.001	<.01	<.01	<.01	1.8	.01	<.001	.08	<.001	.03	.02
3.		<.01	.05	<.001	<.01	.01	<.01	< .01	<.01	<.001	.04	<.001	.07	.01
4.	<.001	<.01	.23	<.001	<.01	.03	<.01	.25	.10	<.001	.05	<.001	.05	<.01
5.	<.001	<.01	.11	<.001	<.01	.02	<.01	.16	.05	<.001	.01	<.001	.04	<.01
6.	<.001	<.01	.10	<.001	<.01	<.01	<.01	.75	.04	<.001	.03	<.001	.04	<.01
7.	.001	<.01	.16	<.001	.02	.03	<.01	1.4	.03	<.001	.53	<.001	.03	.02
8.	.002	<.01	.33	<.001	.01	.04	<.01	3.0	.02	<.001	.17	<.001	.04	.02
9.	.002	<.01	.51	<.001	.04	.08	<.01	.25	.07	<.001	.20	<.001	.53	<.01
10.		<.01	.22	<.001	.03	.05	.01	.20	<.01	<.001	< .01	<.001	.63	.01
11.		<.01	1.4	<.001	.04	.07	.02	.90	<.01	<.001	.50	<.001	.46	.01
12.		<.01	.59	<.001	.02	.07	.01	.38	<.01	<.001	.18	<.001	.50	.01
13.	.006	<.01	.75	<.001	.03	.08	.01	.25	.10	<.001	1.1	<.001	.42	.03
14.		<.01	.21	<.001	.04	.08	.01	.65	<.01	<.001	.15	<.001	.71	.01
15.		<.01	.20	<.001	.05	.07	.01	.35	<.01	<.001	.33	<.001	.39	.02
16.		<.01	.20	<.001	.05	.07	<.01	1.8	<.01	<.001	.21	<.001	.72	.02
17.	.005	<.01	<.10	<.001	.01	.03	<.01	9.2	.03	<.001	.32	<.001	.03	.03
18.	.003	<.01	.28	<.001	.03	.08	<.01	.25	.03	<.001	.13	<.001	.35	<.01
19.		<.01	.14	<.001	<.01	<.01	<.01	1.5	<.01	<.001	.10	<.001	.27	<.01
20.		<.01	.15	<.001	<.01	.01	<.01	1.7	<.01	<.001	.12	<.001	.18	.02
21.	.001	<.01	< .10	<.001	.02	<.01	.01	9.0	.02	<.001	.42	<.001	.05	.04
22.		<.01	.14	<.001	<.01	.01	.01	1.8	<.01	<.001	.12	<.001	.22	.02
23.		<.01	.07	<.001	<.01	.01	<.01	.44	<.01	<.001	.08	<.001	.09	.01
24.		<.01	.13	<.001	.02	.01	.01	8.2	<.01	<.001	.33	<.001	.13	.04
25.	<.001	<.01	.11	<.001	.01	.01	.01	6.8	.06	<.001	.39	<.001	.05	.05
26.		<.01	.13	<.001	.02	.01	.01	7.3	<.01	<.001	.52	<.001	.13	.06
27.	<.001	<.01	.21	<.001	.01	.03	.01	5.3	.04	<.001	.32	<.001	.06	.02
28.	<.001	<.01	< .10	<.001	<.01	<.01	<.01	1.4	<.01	<.001	.06	<.001	.03	.01
29.	<.001	<.01	< .10	<.001	<.01	<.01	<.01	.35	<.01	<.001	.05	<.001	.05	.01
30.	<.001	<.01	< .10	<.001	<.01	<.01	<.01	.35	<.01	<.001	.07	<.001	.09	.02
31.		<.01	.10	<.001	<.01	<.01	<.01	2.0	<.01	<.001	.15	<.001	.17	.02
32.	<.001	<.01	.05	<.001	<.01	<.01	<.01	5.0	.01	<.001	.30	<.001	.03	.02

IX. BIOLOGICAL CONDITIONS

Biological conditions of waters in this basin are generally fair to good (Ref. 31). Cold water habitats include the upper reaches of Pryor Creek and the Little Bighorn River plus the Bighorn River for some 10-20 miles below Bighorn Lake (Reservoir). Various small streams and farm ponds are also cold water habitats. The Tongue River Reservoir and Bighorn Lake contain both cold and warm water fishes. The lower reaches of the larger tributary streams (Bighorn and Tongue Rivers) and the Yellowstone River are warm water habitats as are many farm ponds (Ref. 31, 32). Major fish species include brown and rainbow trout, channel catfish, sauger, crappie, walleye, goldeye, and paddlefish (Ref. 33).

The Bighorn River is an excellent trout stream from Bighorn Dam down to about St. Xavier. Brown and rainbow trout are both present in this reach with the browns also found in limited numbers below St. Xavier. The Bighorn River becomes a warm water habitat in its lower reach. This change is not due primarily to temperature but to an influx of sediment from Soap, Rotten Grass, and Beauvais Creeks and from Pass Creek via the Little Bighorn River. Such sediment problems may relate to poor grazing practices in the area, especially extensive bank trampling. Sauger and channel catfish are common in the Bighorn River below St. Xavier; a few walleyes along with the brown trout are also present. Goldeyes become very numerous in lower portions of the Bighorn River and in the Yellowstone River below their confluence. If the sediment inputs into the Bighorn River were eliminated it could conceivably become a good trout fishery downstream to the Yellowstone (Ref. 31).

Large silt loads in the major tributaries of the Bighorn River prevent these streams from being excellent trout fisheries, especially in the lower reaches. The headwaters of Soap and Rotten Grass Creeks contain mainly brook trout but have some cutthroat and rainbow (Ref. 31).

The Little Bighorn River above Crow Agency is a good trout habitat. Brown trout predominate in this reach. Below Crow Agency increased water temperatures result in a predominance of channel catfish and sauger. Increased sediment loads also contribute to this change. Lodge Grass Creek, a tributary of the Little Bighorn River, is a fair trout fishery. Brook and cutthroat trout are common in the upper reaches while brown trout are common in the warmer lower reaches. Lodge Grass Reservoir (Willow Creek Lake) has a fair number of rainbow trout. Owl Creek, another tributary to the Little Bighorn River, is not a suitable habitat for game fish due to its large silt loads (Ref. 1).

Biological conditions in Bighorn Lake have been extensively studied (Ref. 34, 16). This reservoir is highly productive at the present time and is moderately well-balanced ecologically. This lake probably represents the major fishery in the Middle Yellowstone Basin as of 1974. Walleyes to eleven pounds, black crappie, and yellow perch are common and locally abundant; these species spawn in the reservoir. Brown, rainbow, and a few cutthroat trout in the reservoir spawn in the small influent streams such as Black Canyon, Big Bull Elk, and Porcupine Creeks. In the silty upper end of the reservoir black bullheads and burbot (ling) are common. Fluctuating water levels during the spawning season are the major problem in the maintenance of this fishery. The eggs are left "high and dry" during the spring drawdown (Ref. 31).

The Yellowstone mainstem from Huntley to Bighorn does contain a few brown trout; in general however, the mainstem fish of the middle basin (Huntley to Miles City) consist of sauger, channel catfish, goldeye, carp sucker, and shorthead redhorse (sucker) (Ref. 35). Paddlefish extend up the Yellowstone to near Forsyth while pallid and shovelnose sturgeon become common below Forsyth (Ref. 1). Near Miles City, some walleye, perch, and crappie are present. Carp are found throughout the basin except in the cold headwater streams of higher altitude.

The dominance of warm water species in the middle section of the Yellowstone River may be caused in part by the introduction of silt from the Clark Fork and other tributaries. This addition could cause increased water temperature plus extensive sediment deposition; the latter aspect could account for the elimination of spawning ground for trout in this reach. The combination of these factors then would severely restrict trout habitat. However, aquatic insects captured from the middle reach of the Yellowstone--plecoptera (stoneflies), tricoptera (caddis flies), and ephemeroptera (mayflies) (Ref. 35)--are indicative of water of good quality. These aquatic insect larvae are generally associated with trout streams (Ref. 36).

The Yellowstone River Pollution Study (1955) (Ref. 37) included evaluations of bottom flora and fauna in the Yellowstone River throughout the basin and of the final 41 miles of the Bighorn River. This study concluded:

> Field and laboratory results demonstrate heavy pollution and ideal conditions for development of taste and odors in the Yellowstone and Bighorn Rivers.

A follow-up study was done by the Montana State Board of Health in 1960 (Ref. 38). The bottom organisms collected during this study indicated favorable ecological conditions existed in the Yellowstone River from Hysham to Miles City and in the Bighorn River just below Hardin and in the Yellowstone River from Billings to Hysham. Through 1963 the Yellowstone River biota was still being affected at Pompeys Pillar by pollution input from the Billings area (Ref. 39). Recent control of pollution sources in the Billings and Hardin areas should have improved the ecological conditions of these river reaches. Such improvements are qualitatively suggested (Ref. 31) with some supportive data as noted but definite documentation is not yet available.

Pryor Creek, the Little Bighorn River, and many of the smaller streams in the basin are apparently degraded by silt and at least partially dewatered by agriculture (Ref. 31, 32). These effects have not been documented. Sediment problems on the larger streams in the basin have been mentioned. In addition to sediment and municipal input problems, oil field discharges pose added difficulties to certain streams in the basin. The larger streams, especially the Yellowstone, Tongue, and Bighorn Rivers, may be severely affected through dewatering from water demands that could result from potential coal development in this region.

The Tongue River and its few small tributaries in Montana are largely warm water habitats. Nevertheless, some trout are maintained in the river below the Tongue River Reservoir by annual planting. Biological conditions of the river and reservoir are generally good; however, the river often carries an excessive silt load during the summer. Fish species in this river are quite similar to those of the Middle Yellowstone River.

The Tongue River Reservoir is somewhat unique in the variety of fish species that can be found--"a few of everything in it..." (Ref. 40). Probably the most representative of native fish in the reservoir would be the crappie, bullhead, and catfish. In addition, brown and rainbow trout are present due to annual planting; such species do not reproduce successfully in these warm waters. In recent years, the reservoir has been planted with walleye (about two pounds as of 1970) and northern pike (3 to 18 pounds as of 1970) (Ref. 40).

The Montana tributaries of the Tongue River are quite small and as a result are not supportive of a good sport fishery. This also applies to the many small tributaries of the Yellowstone River in the basin. However, mouths of these small streams are often utilized as spawning grounds for various warm water species. A minor fishery is located in the upper reaches of Rosebud Creek which is predominated by brook trout (Ref. 31). These waters are relatively cool and clear; with the increased silt loads in the lower reaches, the value of this creek as a fishery declines below Busby.

In general, however, biological conditions in the smaller streams of the basin might be rated as fair. Aquatic insects collected from these minor streams included, like the Yellowstone, plecoptera (stoneflies), tricoptera (caddis flies), and ephemeroptera (mayflies) plus odonate (dragonflies). These aquatic larvae are generally associated with unpolluted, well-oxygenated trout streams (Ref. 35). Hyalella sp. (scuds) were also collected; these amphipods are widely distributed and are abundant in unpolluted, clear waters, including streams, springs, and ponds (Ref. 41).

Most of the above discussion revolves around fisheries due to their major importance and interest to the general populace. As a result much of the biological information that is available for various streams stems from fisheries work. In essence, total biological data is limited although greater efforts have been directed in recent years to various other components of the biological and ecological spectra such as benthic fauna, periphyton flora, river productivity, and so forth. This accessory type of information is ecologically essential for sound fishery evaluation and management.

X. PLANNING NEEDS

Future efforts will be needed in the basin to study a variety of water quality problems and to develop plans for correction and abatement of these problems. Problems that are in need of more effort are primarily those of a non-point nature. These problems arise from various activities which include agriculture, runoff from urban areas, construction projects, inadvertent spills, and natural phenomena. These have been discussed extensively in Section V. Coal mining and electrical generating plants pose other possible pollution problems. Runoff from mined areas, spoil banks, and reclaimed lands are possible sources of pollution that should be investigated more intensely. Although the coal fired generating plants proposed and those presently being built in the basin are to be closed systems as regards the water, i.e., no thermal or wastewater discharge; plants of similar design have had discharges when upsets occur. There is, also, the possibility of a significant amount of stack emissions getting into surface water systems either by direct fallout or runoff from lands upon which the stack emissions have fallen. Dewatering of the streams in the basin, especially the Yellowstone River, for increased municipal, industrial, and agricultural development, lowers the dilution capability and may therefore make presently insignificant pollution sources significant. Continued monitoring in the Middle Yellowstone Basin is necessary to determine the extent and severity of these sources. Any comprehensive monitoring should include biological sampling along with sampling for chemical and physical data. Although definite funding will be necessary before planning of future comprehensive monitoring can be implemented, Section 208 of the Federal Water Pollution Control Act Amendments of 1972 provides grants to areas having special water quality problems, which extend over local jurisdictional boundaries, to develop an overall Water Quality Management Plan for the area. Two areas are presently considering 208 planning: Action for Eastern Montana, Glendive; and the Billings-Yellowstone City-County Planning Board. Both have indicated interest in preparing 208 plans for an area of several counties in their respective regimes. Special water quality problems are resulting both directly and indirectly from energy related developments within the entire Yellowstone Basin.

Based on the results of this study, the following non-point problems need additional investigation. These problems are listed in order of priority.

1. Surface and subsurface water quality changes due to basin energy developments.
2. Irrigation return flow impact on surface and groundwater.
3. Storm drains and urban runoff.
4. Construction projects (subdivisions, roads, bridges, riprapping, etc.).
5. Accidental discharges (spills).

XI. MANAGEMENT STRATEGY AND PLAN

The objective of water quality management is to maintain or enhance the quality of waters within the basin. To accomplish this, management programs and plans must be developed and implemented within the basin. After development and implementation, waters and wastewaters in the basin must be checked to determine actual effectiveness of the management program. Water quality management is an interative process; that is, a plan must be followed, the results checked, the plan modified, and the results again checked. A management strategy contains a number of elements. These are:

1. Permits.

   State and federal pollutant discharge permits are a basic tool in regulating the discharge of effluents to state waters. All discharges under the permit authority, either are or will be permitted or eliminated. The permit program regulates the quantity and quality of discharges of municipal and industrial wastes and certain agricultural wastes, including discharges from confined feeding operations and from irrigation drainage systems. The discharge permit also is used to regulate effluent from new or expanded discharges. As stream quality data are obtained, the permit can be used to insure that discharging effluents do not cause streams to exceed state water quality standards. All dischargers will be required, under the permit program, to achieve best practicable control technology not later than July 1, 1977. All publicly owned treatment works must achieve secondary treatment by July 1, 1977.

2. Intensive Surveys.

   Intensive water quality surveys are conducted for waters in the basin that have water quality problems. Objectives of intensive surveys are to determine pollution causes and potential means of elimination or abatement of pollutants. As additional water quality problems are identified within the basin, intensive surveys will be made. Intensive surveys also are conducted to determine the impact of specific wastewater discharges, land practices, or water treatment facilities that are installed in the basin.

3. Monitoring.

   Monitoring include a number of activities that provide measurement of chemical, physical and biological quality of water and changes in quality. Monitoring includes:

   (a) self-monitoring required by dischargers that are under the Pollutant Discharge Elimination System permit program

(b) compliance monitoring by the Water Quality Bureau and the EPA to ensure that permitted discharges are in compliance with allowable limits;

(c) periodic sampling and analysis of water at selected stations;

(d) aerial and ground observations of basin waters and practices or facilities that effect water quality;

(e) the use of continuous water quality recording instrumentation to obtain a continuous record of selected water quality parameters;

(f) short-duration surveys of stream segments to determine changes in quality in streams as the water progresses downstream;

(g) evaluation of water quality data to determine trends and to identify problems.

The basic objective of the monitoring effort is to determine the status of water quality and to determine variations in water quality. The monitoring network also is useful for determining the impact of activities within the basin that influence water quality. Such activities include those that potentially degrade water quality, such as logging, mining, and certain agricultural practices; and those activities that may enhance water quality, such as installation of improved treatment facilities.

4. Facilities construction, operation, and maintenance.

Federal and state grant programs are available to assist municipalities in the construction of sewage treatment facilities, which include outfall and interceptor sewers. Such facilities provide improved treatment of wastewaters and reduce the impact of wastewaters on the receiving water body. An integral part of the waste treatment facility program is adequate operation and maintenance of the facilities after construction is completed. The state requires that all operators be certified and the state provides on-the-job training and annual schools for operators.

5. Operation and maintenance.

Periodic inspections are made of municipal and industrial wastewater treatment facilities in the basin. The objective of operation and maintenance inspections is to ensure that waste treatment facilities are operated in a manner that provides the best possible treatment.

6. Information and Education.

Information is made available to the public through bureau publications, talks, technology transfer seminars, and through answering inquiries. Public hearings and environmental impact statements are presented for important or controversial issues in the basin. Information and educational efforts are informing the public of water quality conditions in the basin and factors that can degrade water quality. This effort stresses development of a pollution prevention attitude.

7. Regulations and Guidelines.

   To prevent water quality degradation within the basin, regulations and guidelines that relate to water quality will be made available to residents of the basin through state and county organizations. This includes regulations that influence water and wastewater from subdivisions and private and public water and wastewater facilities. In addition, existing regulations may be changed or updated to control activities within the basin that will degrade water quality. The Department of Health and Environmental Sciences in cooperation with other agencies, will develop guidelines that will abate or eliminate pollution resulting from storm drainage, storm sewer discharges and non-point sources, including irrigation practices, road building, construction, logging practices, overgrazing and other practices. Land use is recognized as a dominant factor controlling water quality in the basin. Those activities which influence land use will be examined to determine how water quality degradation due to improper land uses can be eliminated to be abated.

8. Enforcement.

   Violations of Montana's laws, rules, or permits are investigated and are subject to injunction, civil penalties, or criminal penalties. The rules and regulations upon which enforcement is based are periodically reviewed and updated to insure that Montana's laws and regulations are adequate and can be properly enforced.

9. Program Coordination.

   Montana's water pollution control program will be coordinated with other state, federal and local agencies to ensure that the activities of these groups receive adequate information with respect to their water quality related activities. This includes review of proposed programs, laws, regulations and proposed technical investigations that relate to water quality.

The elements of basin water quality management described above generally are applicable to all basins. Specific steps that will be taken in the Middle Yellowstone Basin are:

1. Permits.

   Permit conditions and progress in meeting compliance schedules will be reviewed for all dischargers in the basin in FY 1976. All permits will be reviewed prior to expiration to determine what revisions are needed for the reissued permits. All dischargers that have not received permits, but are under the NPDES or MPDES, will receive permits in FY 1976.

2. Intensive Surveys.

   In FY 1976 intensive surveys are planned for Armells Creek, the Tongue River and Tongue River Reservoir, and the three active coal mining operations. As additional water quality problems are identified and as funding is available, additional intensive surveys will be conducted.

3. Monitoring.

   See Section XII (Monitoring and Surveillance) for specific basin strategy and plans.

4. Facilities Construction, Operation and Maintenance.

   Inadequate municipal sewage treatment has been ranked according to priority (Page 42) and will be upgraded to meet secondary treatment by July 1977. Industrial treatment of wastewater discharges will meet best practicable treatment by July 1977. Some EPA and state grant funds will be available for municipal sewage facilities. Sewage treatment plant operator training and the operators school will be available for the basin.

5. Operation and Maintenance.

   At least one inspection will be made annually of each municipal sewage treatment facility in the basin. Critical installations will be provided additional inspections when needed and facilities with special operation and maintenance problems will be provided with technical assistance.

   Major industrial dischargers are examined at least twice per year and minor dischargers are examined as needed and as manpower and funding are available.

6. Information and Education.

   The general bureau information and education program will be utilized in the basin. No specific basin programs are planned for the next year.

7. Regulations and Guidelines.

   During the next year the regulatory framework for water pollution control will be reviewed by the bureau attorney. The adequacy of the regulations to prevent pollution will be assessed.

8. Enforcement.

Enforcement actions will be taken as needed for prosecution of violations of the state's water pollution laws and regulations.

9. Program Coordination.

Federal, state and private organizations that have water quality related actions in the basin will be informed of the Bureau's efforts and will be requested to furnish information on these basin programs.

MONITORING AND SURVEILLANCE

Water quality monitoring and surveillance programs represent a major investment of time and funds. Such programs should obtain the needed information at least cost. To properly design a cost-effective monitoring system, a number of factors must be considered including:

1. Adequacy of baseline data in the basin;
2. Status of the stream as a receiving water for pollutant discharges;
3. Data needs for point source discharges under state and federal permit programs;
4. Existing and potential water quality problems;
5. Data needs for enforcement actions;
6. Available time and funding;
7. Existence of other water quality data collection programs in the area.

Flexibility in scope and intensity is an important aspect of a proposed program. A variety of factors can influence an area's water quality; these include industrial, municipal, and agricultural developments, federal and state regulations, and water transfers. With the range of developments that can occur in a basin, a long-term management strategy cannot be efficiently developed. Water quality surveillance and monitoring is directed at short-term conditions (up to five years in the future) and is revised annually.

Monitoring and surveillance recommendations are presented in this report. The detailed basin monitoring and surveillance program is developed by the Water Quality Bureau as part of the annual water pollution control program plan. Monitoring and surveillance activities are conducted by a variety of organizations including communities and industries, federal and state agencies, private individuals and organizations. Commonly, accute problems such as toxic conditions causing fish kills, oil spills, etc. are recognized by basin residents or persons working in the basin.

The following is the recommended monitoring program for the Middle Yellowstone Basin.

1. Compliance Monitoring.

   It is recommended that the following point discharges be checked by the Water Quality Bureau to check compliance with permit conditions.

   Forsyth
   Hardin
   Hysham
   Lame Deer
   Lodge Grass
   Miles City
   Ashland Mutual Self-Help Homes

   Rosebud
   St. Labre
   St. Xavier
   Yellowtail Dam Housing Complex
   Yellowtail Visitors Center
   Yellowtail Dam Power Plant
   Ballantine/Worden
   Crow Agency

Suspended solids, BOD_5, fecal coliforms, and flow will be monitored in all municipal discharges; residual chlorine will be measured where chlorination is provided. Municipal water treatment plant discharges will be monitored for aluminum, suspended residue, turbidity, flow, pH, and residual chlorine.

Similarly, it is recommended that the following industrial discharges be monitored by the Water Quality Bureau to check compliance with permit conditions:

Decker Coal Company, Decker (strip mine)
Westmoreland Resources, Hardin (strip mine)
Soap Creek Associates, Inc., St. Xavier (oil field)
Forsyth Ready-Mix, Forsyth (gravel washing)

Frequency and parameters to be monitored for irrigation return flows have not, as yet, been defined. Feedlots designed are basically as non-discharging facilities.

2. Self-Monitoring.

All waste dischargers under MPDES permit are required to periodically sample and analyze their wastewater and report these results to the Bureau and the Environmental Protection Agency. The parameters to be monitored are specified in the conditions of the permit.

3. Water Quality Surveillance Network.

The water quality surveillance network is composed of water quality sampling stations on streams, waterbodies and groundwater. Surveillance is recommended for the following streams:

Stream	Site
Yellowstone River	At Billings
Sage Creek	At Warren
Pryor Creek	At Huntley
Fly Creek	At Pompeys Pillar
Little Bighorn River	At State Line
Lodge Grass Creek	At Lodge Grass
Owl Creek	Near Lodge Grass
Little Bighorn River	Near Hardin
Bighorn River	Near St. Xavier
Soap Creek	Near St. Xavier
Rotten Grass Creek	At St. Xavier
Tullock Creek	Near Bighorn
Bighorn River	Near Bighorn
Yellowstone River	Near Myers
Sarpy Creek	Near Hysham
West Fork Armells Creek	Near Colstrip
East Fork Armells Creek	At Colstrip
Armells Creek	Near Forsyth

Stream	Site
Yellowstone River	At Forsyth
Rosebud Creek	Near Kirby
Lame Deer Creek	Near Lame Deer
Rosebud Creek	Near Colstrip
Rosebud Creek	Near Rosebud
Hanging Women Creek	Near Birney
Otter Creek	Near Ashland
Pumpkin Creek	Near Miles City
Tongue River	Reservoir discharge
Tongue River	Near Birney
Tongue River	Near Ashland
Tongue River	Near Brandenburg
Tongue River	Near Miles City
Yellowstone River	At Miles City

Recommended surveillance frequency varies from continuously to quarterly and parameters to be monitored generally include flow, sediment, temperature, nutrients, common ions, and coliform organisms.

The actual basin surveillance program is described in the bureau annual water pollution control program plan. Details of sampling frequency and parameters also are described in this plan.

Biological assessment and water quality runs will be carried out at selected sites in the basin. Biological assessments involve periodic quantitative and/or qualitative benthic organism assessments. Water quality runs involve an intense instream survey of a few water quality parameters at a large number of stations. The sampling is designed to measure changes in stream quality as the water moves downstream. Sites selected for these evaluations are described in the Bureau's annual pollution control plan.

4. Aerial and Ground Surveys

Examination of streams and water bodies is done as part of the routine bureau visits to the basin. Other agencies and organizations also commonly notice stream conditions during their basin trips. Detailed aerial surveillance and actual stream examination on foot or by boat is required for selected problems. Armells Creek near Colstrip, for example, should be examined in detail by walking the stream annually.

5. Data Interpretation and Analysis

Surveillance and monitoring activities develop water quality data that must be compared with previous data, water quality standards, permit conditions, etc. Results of water quality testing must be analyzed and interpreted to understand temporal and spatial changes in water quality and determine if the sampling network is adequate to meet program objectives.

XIII. COAL DEVELOPMENT

Coal development presently is a major activity in the basin and is expected to increase in the near future. Water quality problems may arise either directly or indirectly from coal development, coal mining, or coal conversion plants. These facilities will have water quality problems, and increased populations in the basin will cause additional water pollution. Many current studies in the basin are examining coal development impacts and existing and potential effects on water quality.

The impact of energy developments in the Middle Yellowstone River basin will be very dependent on the type of development and will be site-specific. Present energy developments within the basin include coal mining on Sarpy Creek, Armells Creek, on the Tongue River near the Tongue River Reservoir, and in the Rosebud Creek drainage. Of these coal mines, only two--the mine on Sarpy Creek and on the Tongue River--have waste discharges to waters of the state. The impacts of these discharges have been described in other sections of this report.

The potential for water quality degradation due to energy developments including coal mining and energy conversion plants and increased populations is enormous. There is a great deal of statewide concern about the impact of such developments on both surface and groundwater quality in the basin. State land reclamation and water pollution regulations are a basic regulatory factor in controlling environmental impacts on water quality. As mentioned in this report, there is considerable effort being directed at evaluation of the impact of energy developments in this portion of Montana. Presently, water quality effects of energy developments are not well understood. The development of coal, however, is in its infancy and will greatly expand within the next decade. Information obtained from existing and proposed studies should indicate the extent and magnitude of energy impacts on water quality. Presently, it is too early to accurately assess either the short or long-term consequences of energy development.

Many potential water pollutants due to coal mining have been identified. These include degradation of ground and surface water due to leaching of salts from spoil piles, increased sedimentation due to runoff from disturbed lands, and increased stress on the water resources due to increased populations.

Although some technical work has been done on these problems, the results to date are inconclusive and variable. Land reclamation techniques used at a mine site will effect water movement and water quality. Land reclamation is in an experimental status, thus, the impact on water quality cannot be accurately assessed. Within the next five years, the impact of coal mining on water quality should be better understood.

Coal conversion processes including coal-fired power generation and gasification are another threat to water quality. These processes involve not only mining, but the conversion of coal with its attendant pollution problems. Due to the wide variety of conversion processes, water quality problems cannot be predicted. The evaluation of pollution potential will be both site and process dependent.

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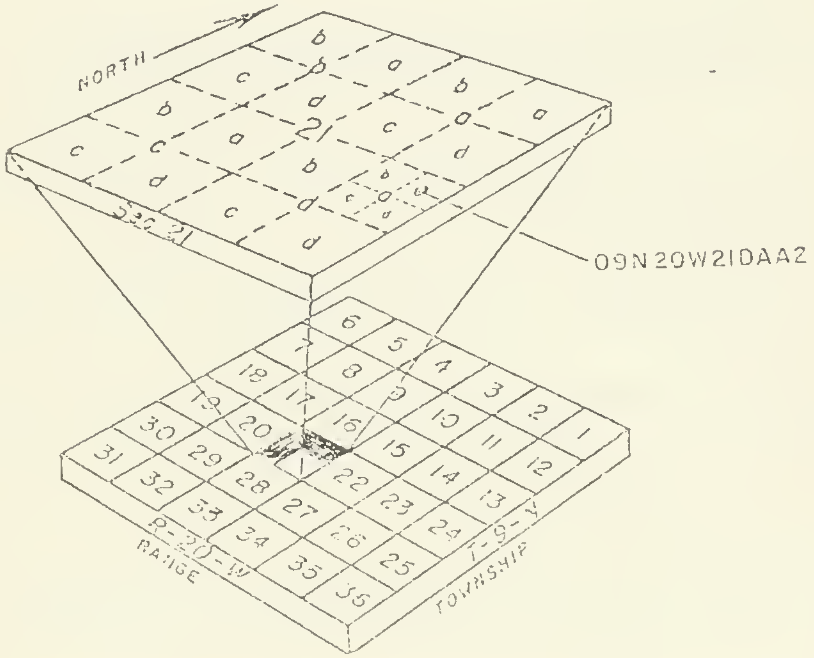
SYSTEM FOR GEOGRAPHIC LOCATION OF FEATURES

Wells, springs, water-sampling locations, and stream-gaging locations are assigned numbers based on the system of land subdivision used by the U. S. Bureau of Land Management. The number consists of twelve characters and describes the location by township, range, section, and position within the section. The figure below illustrates the numbering method. The first three characters of the number give the township, the next three characters the range. The next two numbers give the section number within the township, and the next three letters describe the location within the quarter section (160-acre tract) and the quarter-quarter section (40-acre tract), and the quarter-quarter-quarter section (10-acre tract). These subdivisions of the 640-acre section are designated a, b, c, and d in a counterclockwise direction, beginning in the northeast quadrant. If there is more than one feature in a 10-acre tract, consecutive digits beginning with 2 are added to the number. For example, if a water-quality sample was collected in sec.21,T.9N.,R20W, it would be numbered 09N20W21DAA2. The letters DAA indicate that the well is in the NE¼ of the NE¼ of the SE¼, and the number 2 following the letters DAA indicates there is more than one water-quality sampling location in this 10-acre tract.



APPENDIX B

MONTANA STATE DEPARTMENT OF HEALTH
AND
ENVIRONMENTAL SCIENCES

MAC 16-2.14(10)-S14480 WATER QUALITY STANDARDS

(1) Policy statement. The following standards are adopted to establish maximum allowable changes in water quality and establish limits for pollutants which affect prescribed beneficial uses of state waters. The department adopts as a rule the policy that best practicable treatment and control of waste, activity and flow is to be provided to maintain dissolved oxygen and overall water quality at the highest possible levels, and water temperatures, coliform bacteria concentrations, dissolved chemical substances, toxic materials, radioactivity, turbidities, color, odor and other deleterious substances at the lowest possible levels.

(2) Application of standards. The water quality standards are composed of water-use classifications [section (4)], water-use descriptions and specific water quality criteria [section (5)], and general water quality criteria [section (6)].

(a) General water quality criteria apply to all state waters except where in this rule specific water quality criteria are more applicable to a specific water-use classification.

(b) In order to carry out the objective of the rule, existing discharges to state waters shall be brought into compliance with the standards as soon as practicable, and in no case later than three years from the effective date of the rule.

(3) Definitions. Unless statutory definition or the context otherwise requires in this rule:

"Conduit" means any artificial or natural duct, either open or closed, for conveying liquids or other fluids.

"Dewatered stream" means a perennial or intermittent stream whose water has been removed for one or more beneficial uses.

"EPA" means the U. S. Environmental Protection Agency.

"Intermittent stream" means a stream or portion of a stream that flows only in direct response to precipitation; it receives little or no water from springs and no long-continued supply from melting snow or other sources.

"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been applied. Conditions resulting from dams in existence as of July 1, 1971 are natural.

"Mixing zone" means that volume of state water wherein any pollutant may exceed allowable water quality standards.

(4) Water-use classifications.

Yellowstone River:

Clarks Fork Yellowstone River (mainstem) from Jack Creek to the Yellowstone River	B-D_2
Tributaries to the Clarks Fork Yellowstone River from Jack Creek to the Yellowstone River except the West Fork of Rock Creek listed below	B-D_1
West Fork of Rock Creek drainage to the Red Lodge water supply intake	A-Open-D_1
Remainder of West Fork of Rock Creek drainage	B-D_1
Yellowstone River drainage from the Billings water supply intake to the North Dakota state line except the tributaries listed below	B-D_3
Pryor Creek drainage	B-D_1
Big Horn drainage above but excluding William's Coulee near Hardin	B-D_1
Big Horn drainage from and including William's Coulee to the Yellowstone River except the Little Big Horn listed below	B-D_2
Little Big Horn drainage above and including Lodgegrass Creek near Lodge Grass	B-D_1
Remainder of the Little Big Horn drainage	B-D_2
Tongue River (mainstem) from Tongue River Reservoir to but excluding Prairie Dog Coulee	B-D_2
Remainder of the Tongue River drainage	B-D_3

(c) A-Open-D_1 classification.

(i) Water-use description. Water supply for drinking, culinary and food processing purposes suitable for use after simple disinfection and removal of naturally present impurities. Water quality is to be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply. Where the waters are used for swimming or other water-contact sports, analyses are to be made by the utility owner and the department to determine if a higher degree of treatment is required for potable water use.

Waters, if shown to meet the A-Closed criteria, may be so classified by the department at the request of the utility owner. State waters within the boundaries of national parks and nationally designated wild, wilderness or primitive areas in the state are classified A-Open-D_1 except those adjacent to developed areas such as Snyder Creek through the community of Lake McDonald and Swiftcurrent Creek below the Many Glacier Chalet, both in Glacier National Park. Also, Georgetown, Flathead and Whitefish lakes and Lake Mary Ronan are classified A-Open-D_1 as are some streams presently used for domestic water supply.

(ii) Specific water quality criteria.

(aa) The average number of organisms in the coliform group is not to exceed 50 per 100 milliliters where demonstrated to be the result of domestic sewage.

(ab) Dissolved oxygen concentration is not to be reduced below 7.0 milligrams per liter.

(ac) Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 is to be less than 0.5 pH unit. Natural pH outside this range is to be maintained without change. Natural pH above 7.0 is to be maintained above 7.0.

(ad) No increase above naturally occurring turbidity is allowed.

(ae) A 1° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 66° F; within the naturally occurring range of 66° F to 66.5° F, no discharge is allowed which will cause the water temperature to exceed 67° F; and where the naturally occurring water temperature is 66.5° F or greater, the maximum allowable increase in water temperature is 0.5° F. A 2° F per hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55° F, and a 2° F maximum decrease below naturally occurring water temperature is allowed within the range of 55° F to 32° F.

(af) No increases above naturally occurring concentrations of sediment, settleable solids or residues, which adversely affect the use indicated, are allowed.

(ag) Concentrations of toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metals, after treatment for domestic use, are not to exceed the recommended limits established in the 1962 U. S. Public Health Service Drinking Water Standards or subsequent editions; an increase of more than 10 percent of the concentration present in the receiving water is not allowed; maximum allowable concentrations are to be less than acute or chronic problem levels as revealed by bioassay or other methods.

(ah) True color is not to be increased more than two units above naturally occurring color.

(d) B-D1 classification.

(i) Water-use description. The quality is to be maintained suitable for drinking, culinary and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary to remove naturally present impurities; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

(ii) Specific water quality criteria.

(aa) The average number of organisms in the fecal coliform group is not to exceed 200 per 100 milliliters, nor are 10 percent of the total samples during any 30-day period to exceed 400 fecal coliforms per 100 milliliters. The average number of organisms in the coliform group is not to exceed 1,000 per 100 milliliters, nor are 20 percent of the samples to exceed 1,000 coliforms per 100 milliliters during any 30-day period.

(ab) Dissolved oxygen concentration is not to be reduced below 7.0 milligrams per liter.

(ac) Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 is to be less than 0.5 pH unit. Natural pH outside this range is to be maintained without change. Natural pH above 7.0 is to be maintained above 7.0.

(ad) The maximum allowable increase above naturally occurring turbidity is 5 Jackson Candle Units except as is permitted in the general water quality criteria.

(ae) A 1° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 66° F; within the naturally occurring range of 66° F to 66.5° F, no discharge is allowed which will cause the water temperature to exceed 67° F; and where the naturally occurring water temperature is 66.5° F or greater, the maximum allowable increase in water temperature is 0.5° F. A 2° F per hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55° F, and a 2° F maximum decrease below naturally occurring water temperature is allowed within the range of 55° F to 32° F.

This applies to all waters in the state classified B-D_1 except for Prickly Pear Creek from McClellan Creek to the Montana Highway No. 433 crossing where a 2° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 65° F; within the naturally occurring range of 65° F to 66.5° F, no discharge is allowed which will cause the water temperature to exceed 67° F; and where the naturally occurring water temperature is 66.5° F or greater, the maximum allowable increase in water temperature is 0.5° F.

(af) No increases above naturally occurring concentrations of sediment, settleable solids or residues, which adversely affect the use indicated, are allowed.

(ag) Concentrations of toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metals, after treatment for domestic use, are not to exceed the recommended limits contained in the 1962 U. S. Public Health Service Drinking Water Standards or subsequent editions; also, maximum allowable concentrations are to be less than acute or chronic problem levels as revealed by bioassay or other methods.

(ah) True color is not to be increased more than five units above naturally occurring color.

(e) B-D_2 classification.

(i) Water-use description. The quality is to be maintained suitable for drinking, culinary and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary to remove naturally present impurities; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

(ii) Specific water quality criteria.

(aa) The average number of organisms in the fecal coliform group is not to exceed 200 per 100 milliliters nor are 10 percent of the total samples during any 30-day period to exceed 400 fecal coliforms per 100 milliliters. The average number of organisms in the coliform group is not to exceed 1,000 per 100 milliliters nor are 20 percent of the samples to exceed 1,000 coliforms per 100 milliliters during any 30-day period.

(ab) Dissolved oxygen concentration is not to be reduced below 7.0 milligrams per liter from October 1 through June 1 nor below 6.0 milligrams per liter from June 2 through September 30.

(ac) Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 9.0 is to be less than 0.5 pH unit. Natural pH outside this range is to be maintained without change. Natural pH above 7.0 is to be maintained above 7.0.

(ad) The maximum allowable increase above naturally occurring turbidity is 10 Jackson Candle Units, except as is permitted in the general water quality criteria.

(ae) A 1° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 66° F; within the naturally occurring range of 66° F to 66.5° F, no discharge is allowed which will cause the water temperature to exceed 67° F; and where the naturally occurring water temperature is 66.5° F or greater, the maximum allowable increase in water temperature is 0.5° F. A 2° F per hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55° F, and a 2° F maximum decrease below naturally occurring water temperature is allowed within the range of 55° F to 32° F.

(af) No increases above naturally occurring concentrations of sediment, settleable solids or residues, which adversely affect the use indicated, are allowed.

(ag) Concentrations of toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metals, after treatment for domestic use, are not to exceed the recommended limits contained in the 1962 U. S. Public Health Service Drinking Water Standards or subsequent editions; also, maximum allowable concentrations are to be less than acute or chronic problem levels as revealed by bioassay or other methods.

(ah) True color is not to be increased more than five units above naturally occurring color.

(l) B-D3 classification.

(i) Water-use description. The quality is to be maintained suitable for drinking, culinary and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary to remove naturally present impurities; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

(ii) Specific water quality criteria.

(aa) The average number of organisms in the fecal coliform group is not to exceed 200 per 100 milliliters nor are 10 percent of the total samples during any 30-day period to exceed 400 fecal coliforms per 100 milliliters. The average number of organisms in the coliform group is not to exceed 1,000 per 100 milliliters nor are 20 percent of the samples to exceed 1,000 coliforms per 100 milliliters during any 30-day period.

(ab) Dissolved oxygen concentration is not to be reduced below 5.0 milligrams per liter.

(ac) Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 9.0 is to be less than 0.5 pH unit. Natural pH outside this range is to be maintained without change. Natural pH above 7.0 shall be maintained above 7.0.

(ad) The maximum allowable increase above naturally occurring turbidity is 10 Jackson Candle Units, except as is permitted in the general water quality criteria.

(ae) A 3° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 77° F; within the naturally occurring range of 77° F to 79.5° F, no thermal discharge is allowed which will cause the water temperature to exceed 80° F; and where the naturally occurring water temperature is 79.5° F or greater, the maximum allowable increase in water temperature is 0.5° F. A 2° F per hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55° F, and a 2° F maximum decrease below naturally occurring water temperature is allowed within the range of 55° F to 32° F.

This applies to all waters in the state classified B-D3, except from the Billings water supply intake to the water diversion at Intake, a 3° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 79° F; within the range of 79° F to 81.5° F, no thermal discharge is allowed which will cause the water temperature to exceed 82° F; and where the naturally occurring water temperature is 81.5° F or greater, the maximum allowable increase in water temperature is 0.5° F.

From the water diversion at Intake to the North Dakota state line, a 3° F maximum increase above naturally occurring water temperature is allowed within the range of 32° F to 82° F; within the range of 82° F to 84.5° F, no thermal discharge is allowed which will cause the water temperature to exceed 85° F; and where the naturally occurring water temperature is 84.5° F or greater, the maximum allowable increase in water temperature is 0.5° F.

(af) No increases above naturally occurring concentrations of sediment, settleable solids or residues, which adversely affect the use indicated, are allowed.

(ag) Concentrations of toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metals, after treatment for domestic use, are not to exceed the recommended limits contained in the 1962 U. S. Public Health Service Drinking Water Standards or subsequent editions; also, maximum allowable concentrations are to be less than acute or chronic problem levels as revealed by bioassay or other methods.

(ah) True color is not to be increased more than five units above naturally occurring color.

(6) General water quality criteria.

(a) The degree of waste treatment required to restore and maintain the standards is to be determined by the department and is to be based on the following.

(i) The state's policy of nondegradation of existing high water quality as described in Section 69-4808.2, R.C.M. 1947.

(ii) Present and anticipated beneficial uses of the receiving water.

(iii) The quality and nature of flow of the receiving water.

(iv) The quantity and quality of the sewage, industrial waste or other waste to be treated.

(v) The presence or absence of other sources of pollution on the same watershed.

(b) Sewage is to receive a minimum of secondary treatment as defined by EPA in accordance with requirements as set forth in the Federal Water Pollution Control Act Amendments of 1972.

(c) Industrial waste is to receive, as a minimum, treatment equivalent to the best practicable control technology currently available (BPCT) as defined by EPA. In cases where BPCT is not defined by EPA, industrial waste is to receive, after maximum practicable in-plant control, a minimum of secondary treatment or equivalent.

(d) For design of disposal systems, stream flow dilution requirements are to be based on minimum consecutive seven-day average flow which may be expected to occur on the average of once in ten years. When dilution flows are less than the above design flow at a point discharge, the discharge is to be governed by the permit conditions developed for the discharge through the waste discharge permit program.

(e) State surface waters are to be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:

(i) Settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines.

(ii) Create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials.

(iii) Produce odors, colors or other conditions as to create a nuisance or render undesirable tastes to fish flesh or make fish inedible.

(iv) Create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life.

(v) Create conditions which produce undesirable aquatic life.

(f) No wastes are to be discharged and no activities conducted such that the wastes or activities, either alone or in combination with other wastes or activities, will violate, or can reasonably be expected to violate, any of the standards; (e.g., in a reach of stream classified B-D_1, the total allowable cumulative increase to naturally occurring turbidity conditions in the reach is 5 Jackson Candle Units).

(g) No wastes are to be discharged and no activities conducted which, either alone or in combination with other wastes or activities, will cause turbidities to exceed those allowed by specific water quality criteria; provided, short-term activities necessary to accommodate essential dredging, channel or bank alterations, stream diversions or other construction where turbidities in excess of the criteria are unavoidable, may be authorized by the department under conditions as it may prescribe.

(h) Methods of sample collection, preservation and analysis used to determine compliance with the standards are to be in accordance with the latest edition of Standard Methods for the Examination of Water and Waste water published by the American Public Health Association or in accordance with tests or procedures that have been found to be equally or more applicable.

(i) For operations of existing water impoundments that cause conditions harmful to prescribed beneficial uses of state waters, it is to be demonstrated to the satisfaction of the department that continued operations will be done in the best practicable manner to minimize harmful effects and will not violate state laws or department rules. New water impoundments shall be designed to provide temperature variations in discharging water that maintain or enhance the existing propagating fishery and associated aquatic life. As a guide, the following temperature variations are recommended: Continuously less than 40° F during the months of January and February, and continuously greater than 44° F during the months of June through September.

(j) Ponds for waste treatment purposes are not to be located in drainage ways where the volume of drainage water from a 10-year storm entering the ponds exceeds one-half the volume of the pond; provided that, subject to approval by the department as to design and maintenance, ponds located in drainage ways for the express purpose of containing emergency oil spills are permitted.

(k) Dumping of snow from municipal and/or parking lot snow removal activities into waters of the state is prohibited without a permit from the department.

(l) Existing discharges to state waters will be entitled a mixing zone as determined by the department.

(m) Until such time as minimum stream flows are established for dewatered streams, the minimum treatment requirements for discharges to dewatered receiving streams are to be no less than the minimum treatment requirements prescribed.

(n) Treatment requirements for discharges to intermittent streams are to be no less than the minimum treatment requirements prescribed.

(o) Pollution resulting from storm drainage, storm sewer discharges, and non-point sources, including irrigation practices, road building, construction, logging practices, overgrazing and other practices, are to be eliminated or minimized as ordered by the department.

(p) Application of pesticides in or adjacent to state waters is to be in compliance with the labeled direction, and in accordance with provisions of the Montana Pesticides Act (Title 27, Chapter 2, R.C.M. 1947) and the Federal Environmental Pesticides Control Act (Public Law 92-516). Excess pesticides and pesticide containers are not to be disposed of in a manner or in a location where they are likely to pollute state waters.

(q) The following radiological criteria shall apply to all waters except those classified as A-Closed:

(i) The average dissolved concentrations (including the naturally occurring or background contribution) of iodine 131, radium-226, strontium-89, strontium-90 and tritium are not to exceed the following concentration limits:

Iodine-131	5 pCi/L
Radium-226	1 pCi/L
Strontium-89	100 pCi/L
Strontium-90	10 pCi/L
Tritium	3,000 pCi/L

For all other radionuclides, the average dissolved concentration limits are to be 1/150 of the corresponding maximum permissible concentration in water for continuous occupational exposure as recommended by the National Committee on Radiation Protection (National Bureau of Standards Handbook 69 or subsequent revisions.)

(ii) For a mixture of radionuclides, the following relationship is to be satisfied:

$$\frac{C_1}{L_1} + \frac{C_2}{L_2} \ldots + \frac{C_n}{L_n} \leq 1.00$$

C denotes the average concentration of the respective radionuclide, and L denotes its concentration limit.

(iii) Where alpha emitters, strontium-90, radium-228, iodine-129, iodine-130 and lead-210 are known to be absent, routine analyses for dissolved gross beta radioactivity (excluding potassium-40 contribution) may be employed to monitor and show compliance with this criterion (except for tritium) as long as the gross concentration does not exceed 100 pCi/L. When these conditions are not met, routine quantitative analyses of individual radionuclides are to be performed to show compliance. Except in cases where tritium from other than natural sources is known to be absent, routine tritium analyses are to be performed to show compliance. (Note: "Absence" means a negligibly small fraction of the specific concentration limit, where the limit for unidentified alpha emitters is taken as the limit for radium-226.)

(iv) For radionuclides associated with suspended material in transport, the average concentration limits are to be 1/150 of the corresponding maximum permissible concentration in water (insoluble form) for continuous occupational exposure as recommended by the National Committee on Radiation Protection. In-stream sedimentation of these materials is not to produce solids beds that are not in compliance with subsections (q) (i) and (q) (ii) (because of leaching) and/or excessive accumulation in native flora and fauna.

(v) Average concentrations are to be computed from monitoring data acquired during the previous 12 months; maximum concentrations are not to exceed three times the average concentration limits specified.

(vi) Variances from concentration limits specified will be permitted only if the contributing source is non-controllable or a natural source. Best available treatment must be provided for man-made discharges, and the exposure received by affected population groups must be within established dose limits.

(r) No wastes are to be discharged and no activities conducted which, either alone or in combination with other wastes or activities, will result in the dissolved gas content relative to the water surface to exceed 110 percent of saturation.

(s) Bioassay median tolerance concentrations are to be based on latest available research results for the materials, by bioassay tests procedures for simulating actual stream conditions as set forth in the latest edition of Standard Methods for the Examination of Water and Wastewater published by the American Public Health Association, or in accordance with tests or analytical procedures that have been found to be equal or more applicable by EPA. Bioassay studies are to be made using the most sensitive local species and life stages of economic or ecological importance; provided other species whose relative sensitivity is known may be used when there is difficulty in providing the most sensitive species in sufficient numbers.

When specific application factors are not available, the factor is to be determined by using methods listed in Water Quality Criteria published by the Federal Water Pollution Control Administration (1968), or by using other methods accepted as equal or applicable by EPA.

(t) Metal limits for the Clark Fork River (mainstem) from the confluence of Warm Springs Creek to the confluence with Cottonwood Creek are:

Material	Average Daily Concentration ug/l	Maximum Instantaneous Concentration ug/l
Total copper	90	180
Dissolved copper	30	40
Total zinc	300	1,000
Dissolved zinc	80	140
Total iron	1,300	2,200
Dissolved iron	150	160
Total lead	100	100
Dissolved lead	100	100
Total cadmium	10	10
Total arsenic	10	16
Total mercury	1	1

Metal limits for Clark Fork River (mainstem) from the confluence of Cottonwood Creek to the Idaho state line are:

Material	Average Daily Concentration ug/l	Maximum Instantaneous Concentration ug/l
Total copper	50	90
Dissolved copper	30	30
Total zinc	100	200
Dissolved zinc	70	80
Total iron	300	1,300
Dissolved iron	150	150
Total lead	50	50
Dissolved lead	50	50
Total cadmium	10	10
Total arsenic	10	10
Total mercury	1	1

(History: Sec. 69-4814, R.C.M. 1947; IMP Sec. 69-4808.2(1)(b), R.C.M. 1947; Order MAC No. 16-1; Adp. 12/31/72; Eff. 12/31/72; AMD, MAC Notice No. 16-2-3, Order MAC No. 16-2-5; Adp. 7/13/73; Eff. 11/4/73; PRIOR p. 16-375; AMD, MAC Notice No. 16-2-31; Order MAC No. 16-2-11; Adp. 7/19/74; Eff. 9/5/74; PRIOR p. 16-387, 391, 393, 393.1, 393.4.).

APPENDIX C.

Table 21

Discharge Permit and Schedule of Compliance Information for Dischargers in the Middle Yellowstone Basin

Facility	NPDES or MPDES Permit No.	Date Issued	Expiration Date	Compliance Schedule
Ballantine/Worden Sewage Lagoon	MT-0020346 Written to SID 308	9/16/74	12/31/76	SER No date specified.
Hysham Sewage Lagoon	MT-0021709	6/14/74	12/31/76	SER No date specified.
Forsyth Sewage Lagoon	MT-0021288	4/30/74	6/30/77	SER 7/1/77
St. Labre Mission School Sewage Lagoon	MT-0022985	12/31/74	12/31/78	None required.
Lame Deer Sewage Lagoon	MT-0023141		12/31/78	SER 7/1/77
Colstrip Sewage Lagoon	MT-0022373	9/16/74	6/30/79	None required.
Lodge Grass Sewage Lagoon	MT-0021890	12/22/74	12/31/78	SER 7/1/77
Crow Agency Sewage Lagoon	MT-0020800	4/30/74	12/31/76	SER 7/1/75
Hardin Sewage Lagoon	MT-0020834	12/22/74	6/30/79	SER 7/1/77
St. Xavier Sewage Lagoon	NO APPLICATION RECEIVED ------------------------------------			

Table 21
(continued)

Facility	NPDES or MPDES Permit No.	Date Issued	Expiration Date	Compliance Schedule
Yellowtail Dam Housing Complex Sewage Lagoon	MT-0020672	6/21/74	12/31/78	SER 7/1/77
Yellowtail Visitors Center	NO APPLICATION RECEIVED			
Yellowtail Dam Power Plant Extended Aeration	MT-0022993	6/21/74	12/31/78	SER 7/1/77
Forsyth Water Treatment Plant	MT-0000957	2/25/74	12/31/76	BPTR 6/1/76
Hardin Water Treatment Plant	NO APPLICATION RECEIVED			
St. Labre Water Treatment Plant	NO APPLICATION RECEIVED			
Crow Agency Water Treatment Plant	MT-0029009	Proposed	12/31/76	None required.
Miles City Water Treatment Plant	MT-0023612	12/31/74	6/30/75	None required.
Soap Creek Oil Field Skimming Ponds	NO APPLICATION RECEIVED			
Westmoreland Resources Coal Mining Settling Pond	MT-0021229	7/24/74	6/30/79	None required.

Table 21
(continued)

Facility	NPDES or MPDES Permit No.	Date Issued	Expiration Date	Compliance Schedule
Peabody Coal Company Settling Ponds	APPLICATION RECEIVED - IN DEVELOPMENT STAGE ----------			
Decker Coal Company Settling Pond	MT-0000892		12/31/76	BPTR No date specified.
Forsyth Ready-Mix Settling Pond	NO APPLICATION RECEIVED ----------			
Allen Propp Feedlot	F-18-B	8/14/73	8/14/78	None required.
Custer-Coulee Cattle Company Feedlot	MT-0022799	8/12/74	3/31/77	None required.
Floyd Warren Feedlot	MT-0022543	10/30/74	7/1/79	None required.
T-Bone Feeders, Feedlot Lot #1	NO APPLICATION RECEIVED ----------			
Lot #2	MT-0023311	8/30/74	6/1/79	None required.
Scott Feedlot	NO APPLICATION RECEIVED ----------			
Enzminger Bros. Feedlot	NO APPLICATION RECEIVED ----------			
Clyde Hawks, Inc., Feedlot	NO APPLICATION RECEIVED ----------			
Daniel Vogel Feedlot	NO APPLICATION RECEIVED ----------			
Rector Cattle Company Feedlot	NO APPLICATION RECEIVED ----------			

APPENDIX D

GLOSSARY

Symbol	Definition
BOD_5	Five-day biochemical demand
cfs	Cubic feet per second
gpcd	Gallons per capita per day
gpd	Gallons per day
gpm	Gallons per minute
JTU	Jackson turbidity unit
lbs/capita/day	Pounds per capita per day
lbs/day	Pounds per day
ml	Milliliter
mgd	Million gallons per day
mg/l	Milligrams per liter
sq. ft.	Square feet
TR	Total recoverable
tpd	Tons per day
μmhos	Micromhos per centimeter
$<$	Less than
$\leq$	Less than or equal to
$\geq$	Greater than or equal to
$\sim$	Approximately
BPT	Best practical treatment
WQB	Montana Department of Health & Environmental Sciences, Environmental Sciences Division, Water Quality Bureau
F & G	Fish and Game, Montana Department of
MDHES	Montana Department of Health & Environmental Sciences
MPDES	Montana Pollutant Discharge Elimination System
NPDES	National Pollutant Discharge Elimination System
BuRec	Bureau of Reclamation
EPA	U. S. Environmental Protection Agency
NOAA	National Oceanographic and Atmospheric Administration
SCS	U. S. Department of Agriculture, Soil Conservation Service.
USGS	U. S. Geological Survey
USPHS	U. S. Public Health Service

MIDDLE YELLOWSTONE RIVER BASIN


WATER QUALITY BUREAU
STATE DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES
EXPLANATION
PAVED ROADS
UNIMPROVED ROADS
RAILROADS
STATE BOUNDARY
COUNTY BOUNDARY
PERENNIAL STREAM
INTERMITTENT STREAM
△ WATER QUALITY SAMPLING SITE
● STREAM FLOW GAGING STATION
■ SEWAGE TREATMENT PLANT
□ SEWAGE TREATMENT LAGOON
◩ WATER TREATMENT PLANT
✳ INDUSTRIAL WATER DISCHARGE
0 2 4 6 8 10
SCALE: 1/4" = 1 MILE
NOTE: THIS MAP WAS COMPILED FROM THE MONTANA STATE HIGHWAY DEPARTMENT COUNTY MAP SHEETS
N
27E
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49E
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9S